(NASA-CR-171697) PROTOTYPE WASH WATER RENOVATION SYSTEM INTEGRATION WITH GOVERNMENT-FURNISHED WASH FIXTURE Final Report, 18 Jan. 1982 - 1 Jun. 1983 (Springborn Labs., Inc., Enfield, Conn.) G3/54

N83-35645

Unclas 36729

CR-171 697

FINAL REPORT

ON

PROTOTYPE WASH WATER RENOVATION SYSTEM INTEGRATION WITH GOVERNMENT-FURNISHED WASH FIXTURE

Contract NAS 9-16501

DRL ITEM 3

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lyndon B. Johnson Space Center
Houston, Texas 77058

Project 6037.10

By

SPRINGBORN LABORATORIES, INC.
Enfield, Connecticut 06082

PERIOD COVERED

January 18, 1982 - June 1, 1983

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES AND LISTS

SUMMARY

The Prototype Wash Water Waste Renovation System was integrated with the Government furnished Spacecraft Utensil/Hand Cleansing Fixture (PWWWRS/SUHCF) into a single payload rack. The system was tested and conforms to the Tentative Wash Water Standards by NASA.

The system is based on a multifiltration concept involving coagulation/flocculation, pressure filtration adsorption and ion exchange developed under Contract NAS 9-15931.

Long-term testing of the PWWWRS system alone produced product water 99 percent soap free.

A trade-off analysis comparing power requirements between PWWWRS and VCD indicates a power advantage of the PWWWRS system.

The system functions as an integrated module and has been demonstrated as functional with repeated cycling.

A preliminary operations manual for the combined system has been prepared.

An additional program is recommended aimed at optimizing the performance of the PWWWRS through:

- Identifying trace organic material(s) in the product water which is not being removed by the adsorbers, and reformulating the soap so as to avoid this component(s) which resists removal,
- Conducting extended testing of the prototype system, evaluating the reliability of system components, and correcting any mechanical or electrical problems which may arise, and
- Evaluating the ability of the GFE microbial check valve to eliminate or minimize the presence of microorganisms in the product water.

(The reverse of this page is blank.)

INTRODUCTION

Longer space flights are becoming more frequent and with a significant number of Life Sciences experiments aboard Shuttle payloads being proposed, it has become necessary for NASA to identify techniques to conserve and reclaim water. Perhaps the single greatest source of contaminated water from such proposed missions is wash water from hand washing and bathing. A typical wash water might contain approximately 0.15 percent soap, 50 ppm sodium chloride, 30 ppm sodium sulfate, lesser amounts of other heavy metal salts, urea, lactic acid and emollients; and trace amounts of miscellaneous suspended and colloidal materials such as hair, lint, viruses, bacteria, grease, and soil. Considering the complex nature of typical wash water contaminants, it is only natural that NASA is considering a multifiltration concept as one possible approach to renovating such water.

During the performance of Contract NAS 9-15369, Breadboard Wash Water Waste Renovation System, Springborn Laboratories, developed a total renovation concept for removing objectionable materials from spacecraft wash water in order to make the water reusable. This concept included ferric chloride pretreatment to coagulate suspended solids such as soap and lint, pressure filtration, and carbon adsorption and ion exchange to remove trace dissolved organics and inorganic salts.

To develop the system concept, Springborn Laboratories designed and constructed a breadboard model which was then used to demonstrate the design adequacy of the various system components as well as the limits on system capacities and efficiencies. For demonstration testing, synthetic wash waters based on both Ivory Soap and ML-11 liquid soap were used.

The culmination of this program was operation of the breadboard model for a period of five days, with approximately 40 processing cycles per day. Over that period, the breadboard generated product water that was well within the Tentative Wash Water Specifications for total organic carbon, specific conductivity, NaCl, etc.

Contract NAS 9-15931 involved development of a "Prototype Wash Water Waste Renovation System", a logical follow-on to the previous program.

One objective of this program was that the prototype system be capable of accommodating variations in soap concentration as well as trace animal wastes as might be found from a typical hand wash operation aboard Shuttle. This unit had to be capable of operating satisfactorily under repeated cycles - as many as forty per day.

It was also a goal that the product water from the prototype system consistently meet the Tentative Wash Water Standards, and be capable of 99% soap removal.

With the exception of certain modifications, the basic design concept used was the same as that employed on the Breadboard Wash Water Waste Renovation System, a "multifiltration" scheme based on coagulation/fluocculation, pressure filtration, adsorption, and ion exchange.

As part of this program, a dispenser was designed and developed which allows for stoichiometric proportioning of ferric chloride solution and liquid soap concentrate; balancing of the two materials ensures optimum precipitation of the soap during pretreatment.

Jet agitation was selected as the optimum mixing technique for blending ferric chloride and soapy wash water during precipitation.

The completed prototype system was operated over a period of seven days, using ML-11 liquid soap. During the extended testing, operating parameters such as soap concentration, and degree of mixing were investigated. All product water was well within the Tentative Wash Water Specifications for conductivity, Total Organic Carbon, Total Nitrogen, and chloride ion concentration.

The purpose of the current program was to integrate the Space Utensil/Hand Cleansing Fixture (SUHCF) and Prototype Wash Water Waste Renovation (PWWWRS) systems and demonstrate the functional adequacy of the combined unit. It was also an objective to verify the ability of the combined systems to produce good quality product water on repeated cycling in accordance with the Tentative Wash Water Standards of the Statement of Work.

With the exception of interfacing with the SUHCF system, the basic system and treatment concepts for the waste water renovation are the same as those employed under Contract NAS 9-15931, Prototype Wash Water Waste Renovation

System. The renovation portion of the combined systems continues to employ a "multifiltration" scheme for the treatment of soapy wash water, based on coagulation/flocculation, pressure filtration, adsorption and ion exchange.

To accomplish these objectives, Springborn Laboratories:

- Conducted long-term testing of the PWWWRS system without the hand cleansing fixture in order to identify the capacities of expendable components, analyze system failures, and demonstrate the ability of the system to process water satisfactorily over an extended period under "mission simulation" conditions.
- Conducted a trade-off analysis in order to compare various water treatment schemes to determine if there was adequate justification for substituting vapor compression distillation in place of the adsorber and/or the ion exchange portions of the renovation system.
- Integrated the renovation and hand wash fixture systems.
- Demonstrated the functional adequacy of the combined systems, and the ability to treat water to the Tentative Wash Water Standards on repeated cycling.
- Prepared a preliminary operations manual which identifies system operations, limitations, routine maintenance, and Q.C. on all expendable items.

This final report summarizes the work completed under Contract NAS 9-16501.

TASK 1: CONDUCT EXTENDED OPERATION OF THE PROTOTYPE WASH WATER RENOVATION SYSTEM

Minor Modifications

Prior to extended operation of the prototype, we have made some minor modifications to the dispenser and mixing chamber portions of the system.

Ferric Chloride/Liquid Soap Dispenser

For construction of the dispenser system under Contract NAS 9-15931, Skinner two-way stainless steel valves (B2DA1 052) were used on the soap side (S1 and S2 in Figure 1) and for corrosion resistance, Nacom Teflon body valves (M 442C1AFR-Ht) were used on the ferric chloride side (F1 and F2 in Figure 1). During demonstration testing, a disparity showed up in the volumes dispensed by each side of the system which was traced to the valves. During operation, the valves themselves act like fluid dispensers by pushing a small volume of liquid ahead of the valve plunger as it closes.

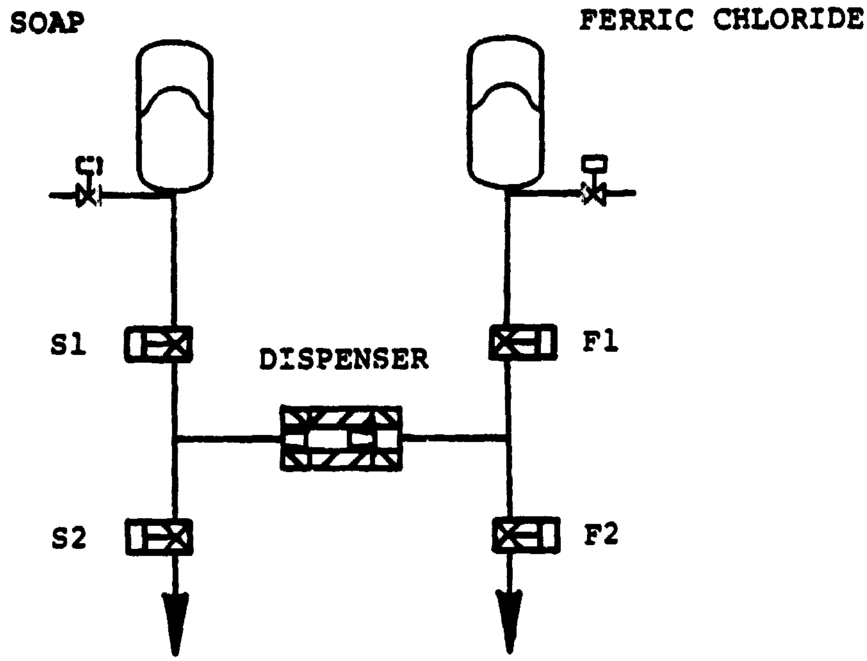
Since the two sets of valves were of different design, this valve-dispensed fraction was different for each side of the dispenser. To eliminate the disparity, the Skinner valves have been replaced by another set of Nacom valves on the soap side of the dispenser.

Mixing Chamber

During demonstration testing of PWWWRS during Contract NAS 9-15931, we experienced stratification of the product water coming from the filters which suggested that there was insufficient mixing of the wash water and ferric chloride in the mixing chamber. To overcome the problem temporarily, the filtrate was circulated through the mixing chamber a second time.

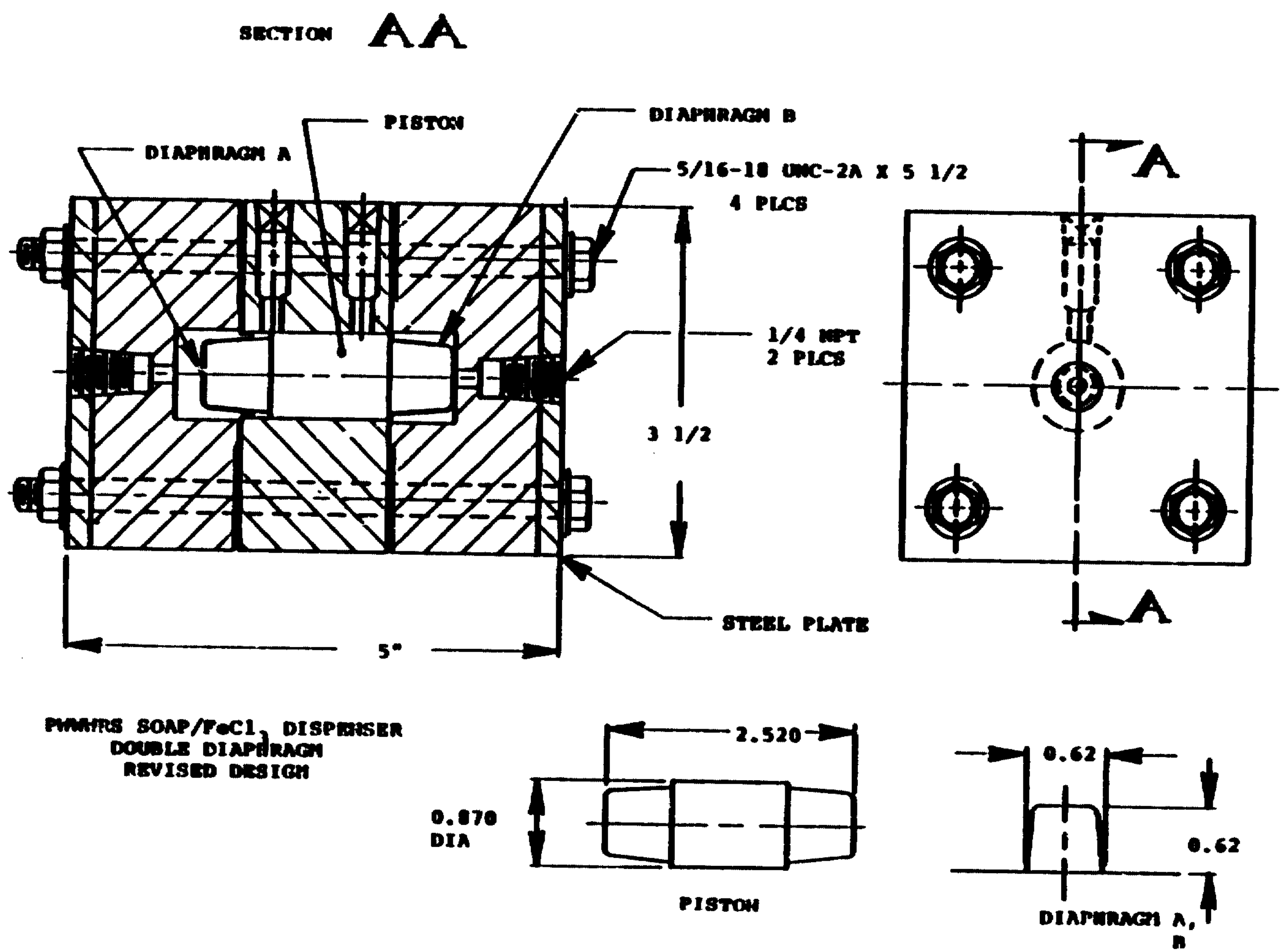
The mixing problem appeared to be two-fold, too low a fluid flow rate through the jet agitator and insufficient mixing between the cylinder at the bottom of the mix chamber and the body of the chamber (see Figure 2).

ORIGINAL PAGE IS
OF POOR QUALITY



FERRIC CHLORIDE
SOAP DISPENSING SYSTEM

Figure 1



PWWWRS SOAP/FeCl3 DISPENSER DOUBLE DIAPHRAGM
REVISED DESIGN

FIGURE 2

To check the flow, we disconnected the bottom plate from the mix chamber, pressurized clean water through the system from the waste storage tank outlet to the agitator at 20 psig, and measured the flow through the SC-10 agitator. The results were as follows:

	Flow Rate through SC-10 Agitator (20 psig)	
	ml/sec	Gallons/Minute
As tested on prototype	14.2 to 14.5	0.22 to 0.23
Approximate rate during demonstration testing	---	~0.13
As stated by supplier	---	8.0
As tested on the bench	300	4.8

The flow rate was more than an order of magnitude slower on the prototype than on the bench; the problem was traced to pressure drop through two "three-way" valves in the line between the waste storage and mix tanks. These valves have orifices in the activated position of only 1/16 inch, with a C_v factor of 0.085 (Skinner B 14DK 1075). These valves were replaced with larger models having higher C_v factors (Skinner AG DB 2127). This resulted in a flow rate three times that previously measured.

The mixing chamber had a comparatively narrow constriction between the cylinder at the bottom of the tank and the main body of the vessel. This one inch diameter hole prevents adequate homogeneous mixing throughout the batch.

Consequently, during demonstration testing, the initial portion of the soapy water transferred to the mix chamber was ferric chloride rich (overdosed), while the last portion of soapy water to enter the vessel was soap rich (underdosed with ferric chloride).

To alleviate this problem, the base of the tank was perforated with 1/2 inch holes to allow diffusion of the water between the vessel body and cylinder.

TABLE 1

SYNTHETIC WASH WATER FORMULATION

Materials	Concentration (ppm
Premixed	
Sodium Chloride	50.00
Sodium Sulfate	30.00
Copper Sulfate	2.50
Potassium Chloride	15.00
Zinc Chloride	7.50
Glucose	1.40
Lactic Acid	7.00
Urea	10.00
Dispensed	
Soap (solids)	as dispensed by the PWWRS
Total	123.40 ppm

The jet agitator mixing head was originally installed horizontally so that the jets sprayed radially within the bottom cylinder. To improve the mixing, the mix head was remounted vertically, so that the spray from the jets flows axially within the chamber, with a portion of the flow directed up into the body of the tank.

Following these modifications, a batch of wash water was generated using 30 nominal shots of soap and water (2cc and 240cc respectively). This waste water was processed as before and the product collected after the filter and before the adsorber. There was no visual evidence of stratification in the filtrate.

Dispenser

Repeated assembly and disassembly of the acrylic dispenser resulted in a great deal of wear and tear particularly on pipe fittings. Therefore, the cavities of the dispenser were remachined. For added durability while still allowing see-through clarity, the dispenser was also fitted with steel end plates. These plates were drilled and tapped for connection with ferric chloride and soap lines, and sealed to the acrylic with machine screws and RTV silicone (refer to Figure 2).

Extended Test Program

In order to gather information on system reliability and the lifetime of expendable components such as filters, and ion exchange resin, the PWWWRS system was operated under simulated end-use conditions for a period of 30 days. This mission simulation was conducted using the following operating parameters:

"washes"/day	-	40
volume of soap/"wash"	-	4.5 cc
volume of water/"wash"	-	270 cc (0.6 pounds)
water renovation	-	on a batch basis every two days

Water spiked with trace amounts of salts, glucose, urea and lactic acid (see Table 1) was poured into a wash basin simulator on the unit. Soap solution (15% ML-11) was dispensed directly into the basin by the PWWWRS. No actual hand washing took place during the simulation.

During each treatment cycle, water was transfered to the mix chamber at 30 psig air pressure where it was allowed to stand overnight in contact with the ferric chloride solution. Treatment of the water through the multifiltration portion of the unit was conducted the following morning again at 30 psig.

To monitor system performance, water samples were taken after the filter, adsorber, and ion exchange columns during the treatment phase.

The following data was gathered during the mission simulation:

- cumulative volume of water processed
- flow rate (time) to the mix chamber and through the "multifilters" for each batch of water processed
- pressure drop across the filter, adsorber, and ion exchange column
- residual soap in the product water, before and after the absorber, for each batch of water processed
- resistivity on the product water before and after the ion exchanger
- occasional checks on TOC, and total nitrogen on the final product
- weight of the dispenser diaphragms before and after the test

The results of the extended operation are summarized in Table 2. This simulation was equivalent to 60 days of operation under nominal conditions of 20 washes per day.

Overall performance was good throughout the simulation. Final conductivity of the product water was 500,000 ohm-cm or better (less than 1 ppm salt) except when the resin became exhausted. Residual soap content of the product was 0 to 10 ppm.

Transfer time from the waste storage tank to the mixing chamber was consistently 7 to 8 minutes throughout the test (i.e., approximately 3 liters/ minute). This rate proved adequate to prevent stratification of the batch during mixing.

Filter Life

Pressure drop across the filter cartridges tends to build up gradually with the accumulation of soap/ferric chloride sludge on the surface of the filter. After approximately 110 liters of water were filtered, the housing was filled to capacity with sludge, and the pressure drop across the filter approached that of the 30 psig operating pressure. At this point, the filter cartridge was changed (i.e. roughly every ten days). From this data, we estimate that under nominal operating conditions (20 washes/day and 2.25 cc of soap per wash) each filter cartridge will last approximately 40 days. Filter useful life should be planned for 30 days to assure against overfilling the filter housing

Soap removal by the filter was within an acceptable range, and was consistent with results seen both on the bench in jar experiments, and in previous work on the PWWWRS. Under the operating conditions used, the soap concentration in the wash water was approximately 2410 ppm; typical removal rates were as follows:

Residual Soap After the Filter	Percent Soap Removed
High (165 ppm)	93.2
Low (50 ppm)	97.9
Average (approx. 110 ppm)	95.4

Adsorber Performance

Based on the soap analysis of the product water after the adsorber as presented in Table 3, there was no detectable loss of adsorber performance after processing more than 300 liters of water (660 pounds or 80 gallons). Based on 100 ppm average concentration of residual soap going into the adsorbers, there was a soap loading of approximately 30 grams on the two adsorber cartridges in series, by the end of the simulation.

However, final TOC analysis on the product water for batches 7, 10, and 13 (Table 3) indicates that all of the residual organics were not being removed.

TABLE 2

PERFORMANCE OF PWWWRS DURING EXTENDED OPERATION

Treatment Cycle[1]	Cumulative Volume of Water Treated, Liters	Flow Time to Treat thru Multifilters, Minutes	Δ P, psig		Soap Content of Water, ppm		Water Analysis of Final Product Water			
							Salt Content of Water			
			Across Filter	Across Deionizer	Before Adsorber	After Adsorber	Resistivity ohm·cm	ppm as Na Cl	TOC, ppm	TN, ppm
1	22.1	36	14-16	2			483,000	< 1	< 1	
2	44.2	--	11	1	116	7	468,000	< 1		
3	66.2	25	0	4	104	1	390,000	< 1	19	
4	88.3	11[2]	4-12[2]	2-4	119	10	19,500	22	46	
5	110.4	16	22	2	50	11	2,030	> 100	47	
6	132.5	26	11-13	16[3]	114	4	265,000[4]	2	61	
7	154.6	16[2]	3[2]	24	138	0	953,000	< 1	103	4.3
8	176.6	24	3- 7	14-20	120	0	974,000	< 1		
9	198.7	23	14	14	134	0	748,000	< 1		
10	220.8	30	20	8	132	0/4	5,840	> 100	85	4.5
11	242.9	40	29	0	128	0	74,000[4,5]	5		
12	265.0	35	1[2]	29	93	0	896,000[4]	< 1		
13	287.0	30	5	24	54	0	1,700,000	< 1	73	4.6
14	309.1	35	8	21	81	0	1,950,000	< 1		
							1,710,000	< 1		
							2,260,000	< 1		
15	331.2	40	10-17	12-19	165	0	1,380,000	< 1		
							900,000	< 1		
							67,800	5		

(1) 80 "washes" per cycle treated on a batch basis, 160 ea 2.25 cc shots of soap, 270 cc water/"wash"
(2) fresh filter
(3) valve down stream of D. I. Unit, plugged with resin
(4) fresh ion exchange resin
(5) bad batch of resin

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 3

ADSORBER PERFORMANCE
TOTAL ORGANIC CARBON (TOC)

Treatment Cycle	Before Adsorber				TOC After Adsorber	Final TOC
	Soap ppm (1)	Soap TOC (2)	Total TOC	Non-Soap TOC (2)		
7	138	104	181	77	73	103
10	132	99	144	45	68	85

(1) by carbon tetrachloride extraction and IR for carbonyl (5.75 u)

(2) by calculation from soap analysis

To aid in identifying where the final TOC was originating, additional analyses were conducted on batches 7 and 10 both before the adsorber and after adsorber but before the deionizer (Table 3). The "before adsorber" data revealed that there was between 45 and 77 ppm TOC that could not be accounted for by fatty acid soap. In addition, this non-soap TOC was not being removed by the adsorbers. Possible sources for this organic component are:

- The deionized water. TOC analysis on the water found 22 ppm TOC. This could be from the ion exchange resin, but is more likely from the incoming water.
- The glucose, urea, and lactic acid added to the synthetic wash water. These only account for approximately 5.4 ppm of the TOC, however.
- The most likely source for the non-soap TOC is a hydrophilic component(s) of the soap solution, possibly an emollient such as glycerin.

Further work with the soap manufacturer and additional analysis to identify the organic material is suggested as a future program.

Comparison of the TOC after the adsorber and final TOC in Table 3 indicates that a small amount of organic material was being put back into the water by the ion exchange resin. According to York Research, this is not unusual, particularly with fresh ion exchange resin as has been used during the mission simulation.

TON data in Table 2, is consistent at approximately 4.5 ppm; this is equivalent to the 10 ppm urea being added to the synthetic wash water and indicates that for batches 7, 10, and 13 none of the urea is being adsorbed.

Ion Exchange Life

Data from the mission simulation is plotted in Figure 3 as cumulative volume of water versus conductivity for three separate resin refills. The conductivity of the water began to drop (electrolyte content goes up) significantly after approximately 50 liters of water have been treated, and by 70 liters the resin was nearly expended. With approximately 960 ppm of K Cl in the wash water, this volume of water equated to an exchange capacity of 67 grams of K Cl for 1/16 ft^3 of IRN-150 resin.

RESISTIVITY OF RECLAIMED WASH WATER VERSUS
CUMULATIVE VOLUME OF WATER PROCESSED

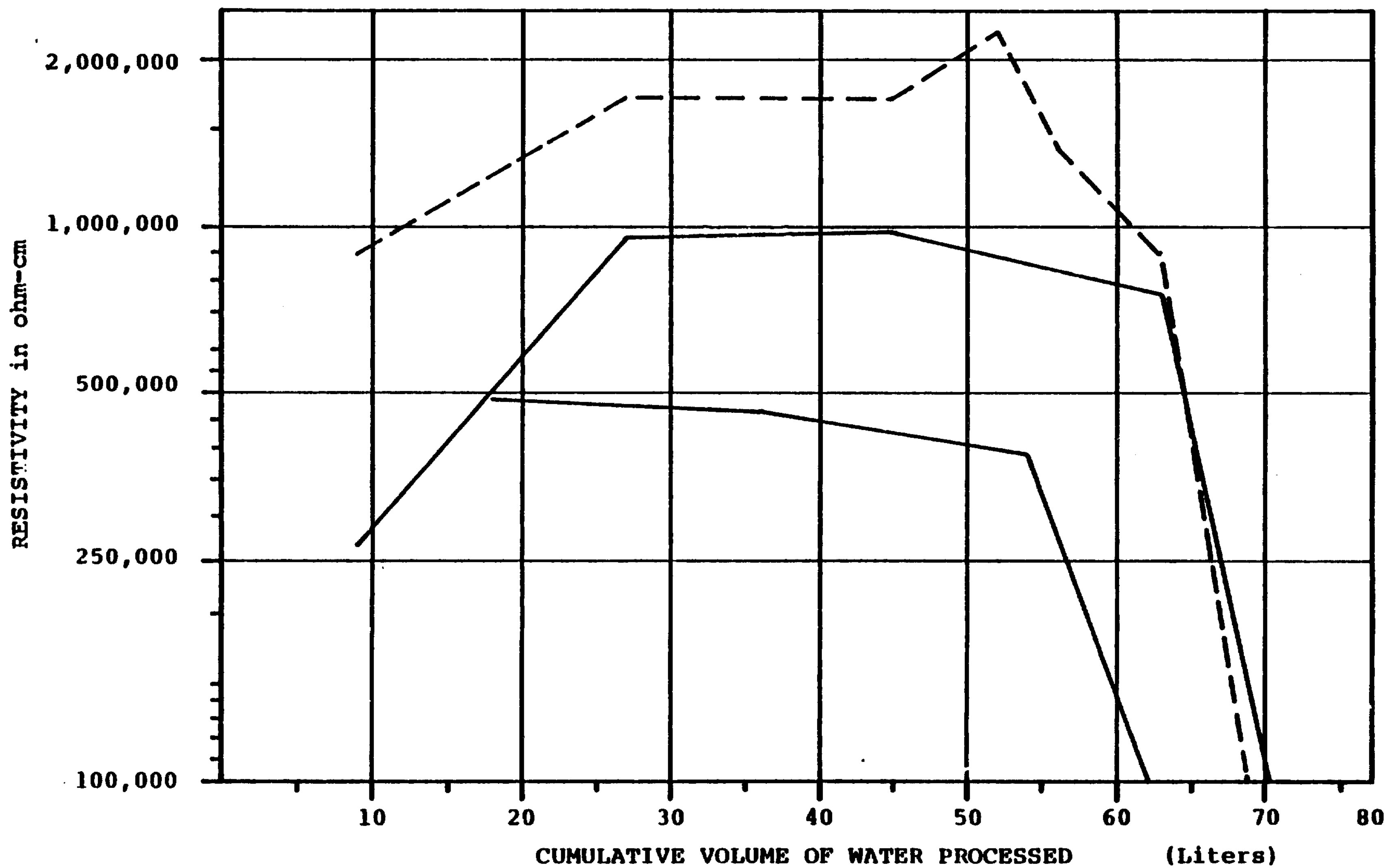


FIGURE 3

During operation under nominal conditions of 20 washes per day, 0.4 pounds of water per wash and 2 cc of soap per wash (750 ppm KCl) the ion exchange resin refills (1/16 cubic foot) should last approximately 21.7 days.

During the test, there was a build up of pressure drop across the T_3 ion exchanger. This was traced to plugging of a solenoid valve with resin particles from the ion exchanger. The unit was repaired to prevent future loss of resin.

The adsorber units offered little pressure drop; pressure drop throughout the simulation was between 1 and 2 psig.

Dispenser Performance

During the 30 days of testing, the dispenser and diaphragms were subjected to 2400 cycles. At the end of the test, there was no visual evidence of cracking or crazing in either diaphragm.

During the test, the diaphragms gained 0.9% and 1.2% weight on the ferric chloride and soap sides of the dispenser respectively. On drying, the ferric chloride diaphragm lost most of this weight gain which was presumably water. The soap diaphragm retained most of its weight gain on drying; this retained weight was likely fatty acid or possibly lanolin from the soap. In either case, it is not expected that these small weight gains will have a significant effect on the lifetime of the diaphragms.

Malfunctions

The only problem encountered during the 30-day simulation was plugging of the valve directly under the mixing chamber during treatment of the mixed wash water through the multifilters. The plugging was caused primarily by pieces of hard floc which lodged in both the entrance port and orifice of the solenoid valve. This problem occurred on approximately half of the batches that were treated, and required dismantling and cleaning of the valve each time.

To correct this problem, the Skinner Model B2DA1 052 two way solenoid valve was replaced by a motor driven ball valve (Jenkins Model 1350 1/2" ball valve with Model 212 electric motor actuator). The "straight-through" design of this valve eliminated any further plugging of the line between the mix chamber and filter housing.

TABLE 4

PRODUCT WATER QUALITY VS TENTATIVE WASH WATER STANDARDS

	Standard	Mission Simulation: Final Product Water
Total Organic Carbon (TOC), mg/l	200	19 to 103
Specific Conductivity, $umho\text{-}cm^{-1}$ (resistivity ohm·cm)	2000 (500)	0.5 to 2 (400,000 to 2,000,000)
pH	5 to 7.5	6.3
Ammonia, mg/l	5	
Turbidity, ppm SiO_2	10	None
Color, Pt-Co Units	15	None
Foaming	Non persistent more than 15 seconds	Non persistent less than 5 seconds
Odor	Non objectionable	None
Total Dissolved Solids (TDS), mg/l	1500	1 (1)
Urea, mg/l	50	10
Lactic Acid, mg/l	Reference only	---
NaCl, mg/l	1000	1 (1)
Microorganisms, Number per ml	0	---

(1) as a function of conductivity

Overall Performance

The overall performance of the PWWWRS was good producing renovated wash water that was well within the Tentative Wash Water Specifications (see Table 4).

During sampling and analysis throughout the run, it was noted that the samples after the adsorber, although clear and water white when taken, developed a fine reddish-brown precipitate on standing. This material was apparently elemental iron resulting from a slight overdosing of the wash water with ferric chloride.

Of course, during normal operation, the water after the adsorber passes directly into the deionizer, and the precipitate does not have a chance to develop. The iron, then presumably in ionic form, is removed by the ion exchange resin. No color or precipitate developed in samples taken after the deionizer.

Following the mission simulation, the two in-series activated charcoal adsorber cartridges were cut open and examined. There was no evidence of microbial growth in either cartridge, but there was some accumulation of unfiltered floc material in the porous plastic distributor plates at the ends of the first adsorber cartridge. No such floc was evident in the second adsorber.

TASK 2: CONDUCT A TRADE-OFF ANALYSIS TO COMPARE VARIOUS WATER TREATMENT SCHEMES

As the PWWWRS existed at the completion of Contract NAS 9-15931, the treatment concepts of coagulation, filtration, adsorption and ion exchange appeared effective, but long-term performance was untested. Preliminary testing has indicated that the treatment concepts are suitable, but alternative methods have not been examined closely. Specifically, there exists the possibility that the use of distillation in place of adsorption and ion exchange or just ion exchange might be more energy, space, and weight efficient.

Therefore, a trade-off analysis was conducted in order to compare weight, space, and power requirements as well as system complexity for the following treatment schemes:

- Present PWWWRS with adsorber and ion exchange columns,
- PWWWRS without ion exchange followed by occasional vapor compression distillation (VCD),
- PWWWRS without ion exchange and adsorber columns followed by occasional VCD, and
- VCD alone.

VCD Units

The second and third schemes listed above assume that product water from PWWWRS will be recycled and that VCD will be performed only when the electrolyte or total organic contents (TOC) in the filtrate reach unacceptable levels. We have assumed that such a VCD unit would be available aboard shuttle and would be of sufficient size and capacity to handle processing of occasional PWWWRS product water.

The VCD unit to be employed would be similar to those preprototypes being developed by Life Systems and Lockheed Missiles and Space Corporation. Representative operating parameters for such units appear in Table 5. The nominal values listed at the bottom of the table are those being used in the trade-off analysis.

TABLE 5

PREPROTOTYPE VAPOR COMPRESSION DISTILLATION UNIT OPERATING PARAMETERS

	Dry Weight		Power	Water Process Rate	Volume	
	Kg (lbs)	Specific Wgt. kg/kg Water/hr	Watt-hrs/ kg Water	kg/hr	m^3	Volume m^3/kg Water/hr
Chemtric, Inc.[1] (1973)	---	---	85 to 150	1.2 to 1.6	---	---
Life Systems, Inc.[1] Preprototype	143 (316)	102	122	1.4	0.47	0.336
Projected Operating[1] Characteristics for Enhanced Orbiter Application	69 (152)	86	103	0.8	0.136	0.172
Lockheed Missiles[2] & Space Corp.	---	---	129 to 133	0.7 to 1.1	---	---
Nominal Values	100 (220)	100	125	1.0	0.25	0.25

(1) Thompson, C. D., "Preprototype Vapor Compression Distillation Subsystem Development", ASME Paper 81-ENAS-25

(2) Johnson, K. L., "Application of Improved Technology to a Preprototype Vapor Compression Distillation VCD Water Recovery Subsystem", ASME Paper 81-ENAS-10

PWWWRS Preprototype

The following assumptions were used in constructing this trade-off analysis:

- The weight of PWWWRS is essentially the present projected weight of the unit as integrated with the hand cleansing fixture (SUHCF) but without the frame. We have assumed that the control panel would be miniaturized using integrated circuitry, but no other weight reduction measures have been assumed.
- The "wash to waste storage" section of the integrated system including the double bladder waste storage/water supply tank is part of SUHCF and not PWWWRS.
- Counters and other control panel displays will use LCD with negligible power requirements.
- Nominal treatment parameters used are as follows:
  - Batch treatment of forty 0.4 lb aliquots of wash water every two days or 7.26 kg (16 lbs).
  - Waste transfer and pretreatment will take 5 minutes.
  - Treatment to water storage will require 30 minutes.
- A 1/8 horsepower compressor will be used to maintain air pressure above all bladder tanks and will operate approximately 1% of the time or 30 minutes over a 48 hour period between treatment cycles.

Operating Parameters

Table 6-A compares operating parameters for PWWWRS with and without adsorbers and/or ion exchange against those of a typical VCD preprototype.

The PWWWRS and VCD preprototypes are approximately the same in terms of weight and volume. Elimination of the adsorbers and ion exchange columns from PWWWRS reduces the overall weight by 13 pounds or approximately 14%. Volume reduction is approximately 13%.

TABLE 6-A

SPECIFICATIONS OF PMAWRS vs VCD PREPROTOTYPES

Type of Unit	Dry Weight kg (lbs)	Dry Weight Specific Wgt. kg/kg Water/hr	Power watt-hrs/kg Water	Water Process Rate kg/hr	Volume m^3	Volume Specific Volume m^3/kg Water/hr
PMAWRS	95 (1) (210)	633	Valves: 3.06 Compressor: 6.17 Relays: 0.52 10.55	0.15	0.305 (2)	2.0
PMAWRS w/o Ion Exchange	89 (196)	593	Valves: 3.06 Compressor: 6.17 Relays: 0.52 10.55	0.15	0.279	1.9
PMAWRS w/o Adsorbers and Ion Exchange	82 (181)	547	Valves: 3.38 Compressor: 6.17 Relays: 0.43 9.[illegible]	0.15	0.264	1.8
Typical VCD	100	100	125	1.0	0.25	0.25

(1) Projected wgt. w/o Frame.

(2) Projected Volume assuming Miniturization of Control Panel.

TABLE 6-B

OVERALL POWER REQUIREMENTS BY TREATMENT SCHEME

Treatment Scheme	Power (Watt hrs/kg Total Water Processed) PMAWRS	VCD	Total Power
PMAWRS	10.6	---	10.6
PMAWRS w/o Ion Exchange (1)	10.6	31.3	41.9
PMAWRS w/o Ion Exchange or Adsorbers (2)	10.0	41.7	51.7
VCD Alone	---	125	125

(1) VCD of every fourth batch

(2) VCD of every third batch

ORIGINAL PAGE IS
OF POOR QUALITY

As expected with a phase change operation, power requirements for VCD on a per kilogram of water processed basis are more than an order of magnitude greater than for PWWWRS. Elimination of the adsorber and ion exchange sections of the PWWWRS has a negligible effect on power requirements. Refer to Table 6-A.

Approximately 60% of the power requirement for PWWWRS is for the air compressor; most of the remainder is for solenoid valves.

The VCD will process a nominal 1.0 kg/hr of product water. This is based on an efficiency or duty cycle of approximately 80%. The PWWWRS is projected to operate approximately 1% of the time (one 35 minute treatment cycle every two days) to treat 7.26 kg of water per batch or an average of 0.15 kg/hr.

If the ion exchange column were removed from PWWWRS, the electrolyte content of the product water would build up at approximately 250 ppm/treatment cycle. Therefore, it would be necessary to run the product water through VCD every fourth cycle in order to meet the tentative wash water standards (Table 7). This would increase the overall power requirement for treatment as outlined in Table 6B.

If the adsorbers were also removed, it would be necessary to distill every third batch in order to keep the TOC level below 200 ppm, again with an increase in power required.

TASK 3: INTEGRATE PROTOTYPE WASH WATER RENOVATION SYSTEM WITH SPACE CRAFT UTENSIL HAND CLEANSING FIXTURE

The assembling of the PWWWRS and government-furnished SUHCF was accomplished in Task 3 without impairing the functions of either system. The soap dispensing function of the PWWWRS was retained and this same function in the SUHCF was eliminated. To maintain stoichiometric balance between soap and ferric chloride, the PWWWRS dispenser system must be used. Compact packaging of the four tanks was made possible with improved volume utilization using smaller size mixing and waste water storage tanks.

The payload envelope constructed of Unistrut® channel members closely resembles a payload rack per JSC-16464A. The flight version of the PWWWRS/SUHCF prototype, will require modifications to conform to interfacing requirements of JSC-16464-A. The prototype assembly demonstrates the feasibility of meeting dimensional requirements.

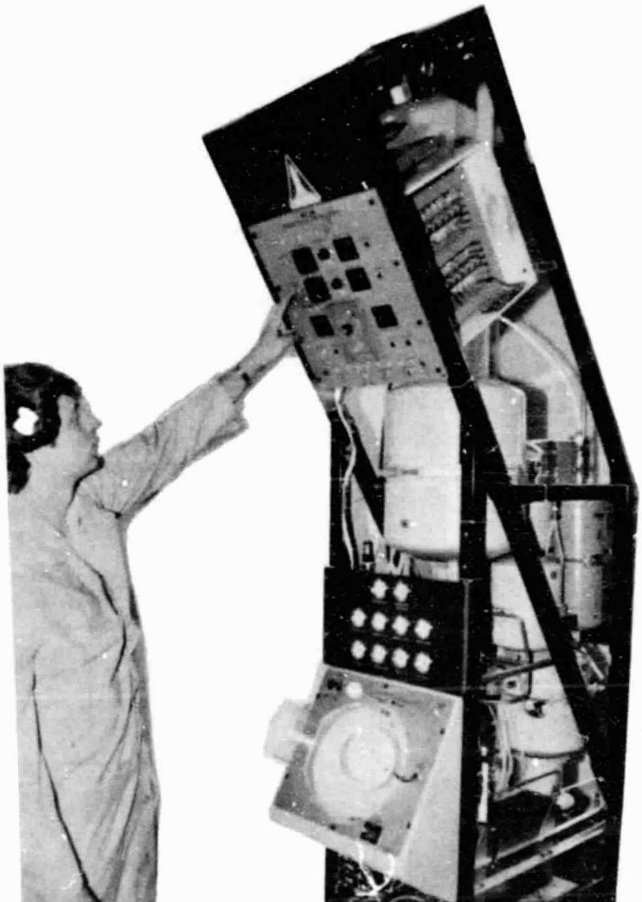
The assembly of the completed prototype PWWWRS/SUHCF is shown on Figure 4.

The assembly of the prototype integrated system was completed in Springborn Laboratories' Engineering Model Shop with components and parts lists that are tabulated on List 9 Parts Summary.

The flow diagram of the integrated system is shown in Figure 5.

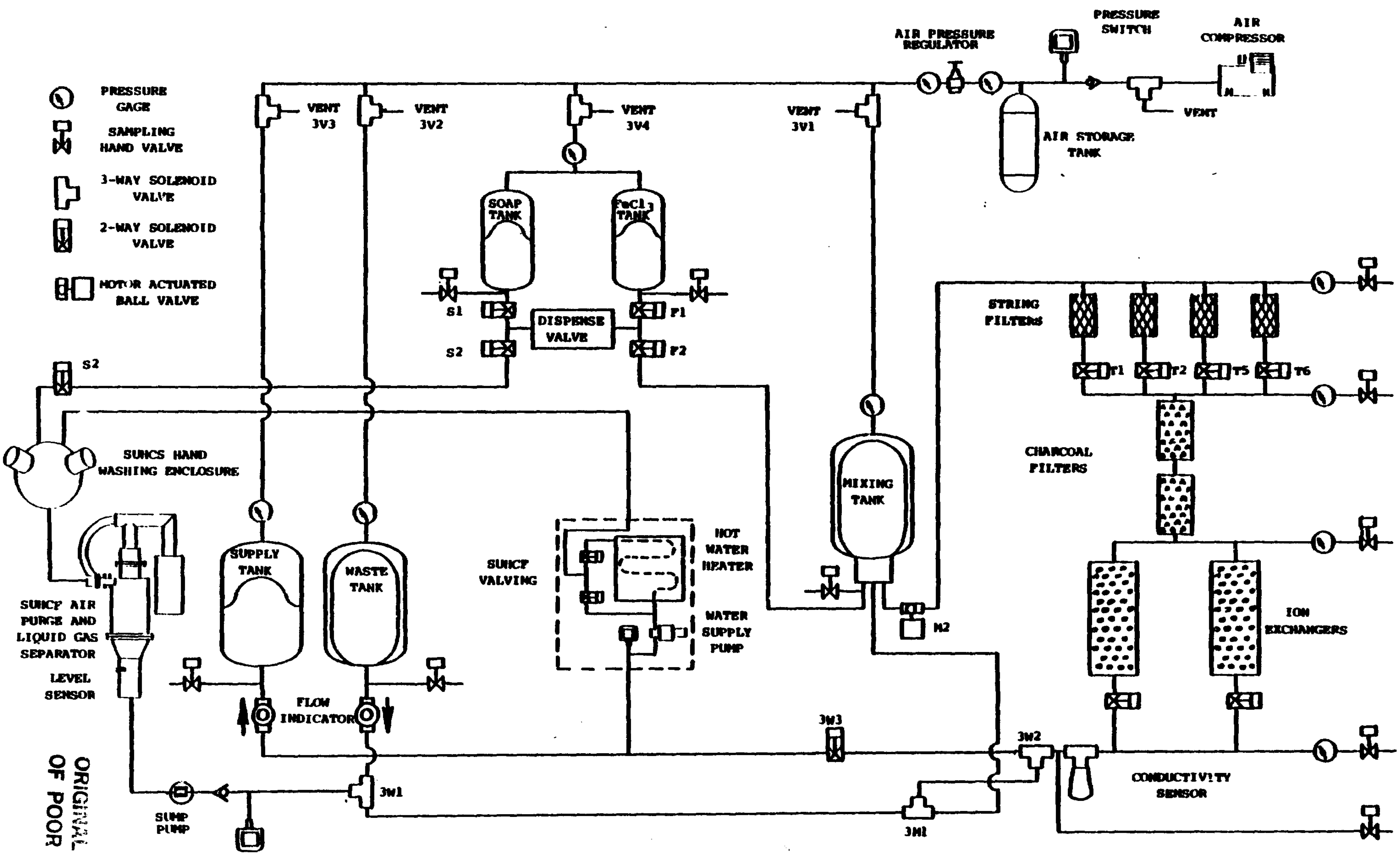
The weight of the integrated prototype is 545 pounds (247 kilograms) which includes the prototype electromagnetic relay panel of 45 pounds (20 kilograms) and frame envelope of 159 lb.

® Registered Trademark



PWWWRS/SUHCF
INTEGRATED PROTOTYPE

FIGURE 4



FLOW DIAGRAM PWWRS/SUHCF SYSTEM

FIGURE 5

ORIGINAL PAGE IS OF POOR QUALITY

TASK 4: TESTING THE COMBINED PROTOTYPE WASH WATER/ HAND CLEANSING FIXTURE TO DEMONSTRATE ITS ABILITY TO FUNCTION WITHIN DESIGN SPECIFICATIONS

The integration of the two systems having been completed in Task 3 of the contract, testing of the unit was conducted. The objectives of these tests were to produce reclaimed water within the tentative wash water standards per Table 7 and observe and correct any malfunctions in the system.

An extended operation of the system was scheduled during which data on water use, pressure drop and flow rates were monitored. The final product water was analyzed for conductivity, soap content, resistivity, PH, total organic content, and total nitrogen content.

The water, spiked with trace amounts of salts, glucose, urea and lactic acid, (refer to Table 1), was poured into the hand cleansing bowl along with soap. Ferric chloride was automatically dispensed to the mix chamber as before, during each cycle. The test series involved (12) twelve treatment cycles with a total quantity of 113 liters (30 gallons of water passing through the system. The system was closed loop except for the addition of the contaminates described previously.

The test was conducted assuming 181 gallons (0.4 lbs) water per wash and 20 washes per day for a 30 day mission simulation, Figure 21, Appendix page A-25.

The procedure followed during the test was as follows:

1. The supply tank was charged with 19 liters (5 gallons of distilled water, PH 5.9.

2. The soap tank was charged with 3.48 liters (0.9 gallons) of soap solution, PH 10.1 (15% SB-40).

3. The ferric chloride tank was charged with 3.48 liters (0.9 gallons) $FeCl_3$ solution, PH 3.0 (3.76% $FeCl_3$).

4. Water from the supply tank was discharged to fill a 1.93 liter (1/2 gallon) jar 4.17 lb - allowing approximately ten 0.4 pound washes .

5. Ten (10) shots of soap solution (21 ml nominal) were collected in a jar at the soap nozzle and added to the 1/2 gallon of water (item 4).

6. Ten (10) shots of $FeCl_3$ solution (21 ml nominal) dispensed concurrently with the soap by the dispenser valve were automatically fed to the mixing chamber in normal operation.

7. The 1/2 gallon of soap-water mix was spiked by the addition of 4 ml mixed salts solution (Table 1).

8. The spiked, soap water mix was poured into the wash basin, drained into the air/water separator sump and transferred to the waste tank.

9. This process was repeated until 3 gallons (11 liters) were in the waste tank.

10. At this point in the test, the unit was switched to treatment/transfer mode and the 3 gallons were transferred to the mixing tank.

11. After a 5-minute delay for flocculation to occur, the mixture in the mixing tank was run through the filter system back into the supply tank.

12. The above process was repeated for the duration of the simulation until a total of 30 gallons had been processed through the unit.

13. During the course of the simulation test, some of the original supply of water was lost either as retained samples or duirng a filter cartridge replacement (T5 filter) and an ion exchange replacement (T3) following sample number 7. Because of this loss of water, cycles after test number 6 were run in nominal 2 gallon batches.

The results of the extended trials are tabulated in Table 8.

TABLE 7

TENTATIVE WASH WATER STANDARDS

TOTAL ORGANIC CARBON (TOC), MG/L	200
SPECIFIC CONDUCTIVITY, UMHO-CM^{-1}	2000
pH	5 to 7.5
AMMONIA, MG/L	5
TURBIDITY, PPM SIO_2	10
COLOR, PT-C UNITS	15
FOAMING	NONPERSISTENT MORE THAN 15 SEC.
ODOR	NONOBJECTIONABLE
TOTAL DISSOLVED SOLIDS (TDS), MG/L	1500
UREA, MG/L	50
LACTIC ACID, MG/L	REFERENCE ONLY
NACL, MG/L	1000
MICROORGANISMS, NUMBER PER ML	0

DISCUSSION OF RESULTS

The product water was well within the Tentative Wash Water Standards for conductivity, pH, total Organic Carbon (TOC), Urea (as a function of TON), and NaCl (as a function of conductivity) as indicated in Table 9. The TOC and TON tests were conducted on batch number 12; the urea concentration, as a function of TON, is higher than found during initial testing of the Stand-Alone PWWWRS unit (Task 1) and indicates a build-up as a result of repeated recycling. Some of the urea is apparently being removed by the adsorbers, however. Were none of the urea being removed, a batch 12 (final concentration) would be in the range of 60 ppm. While the urea concentration is high, it is within the Tentative Wash Water Standards.

Likewise, the TOC result for batch 12 is higher than was found during testing of the Stand-Alone PWWWRS (Task 1) and again reflects the effect of repeated cycling of the water. The identity of this unremoved organic component(s) will be determined as part of a future effort.

TABLE 8

PERFORMANCE OF PWWWRS/SUHCP* EXTENDED OPERATION

Treatment Cycle	Weight of Water Treated lbs.	Cumulative Weight of Water Treated lbs.	Flow Rate Into Mix Chamber gpm	Psig Waste Tank	Flow Rate Thru Multi-Filter Treatment gpm	Filters & Absorbers In Use	ΔP, Psig		Soap Content of Water ppm	Water Analysis of Final Product Water					
										Salt Content of Water					
							Across Filters	Across Deionizer		Conductivity micro-mhos cm^{-1}	Resistivity ohm-cm	ppm as NaCl	pH	TOC ppm	Tn ppm
1	25	25	.732	17/30	.140	T_2, T_4	9	16		3.5968	277,344	< 2	5.40		
2	25	50	.968	18/30	.194	T_2, T_3 (1)	18	3	<1	2.6304	379,688	<2	6.00		
3	25	75	.918	18/30	.182	T_2, T_4	20	2							
4	25	100	.937	18/30	.172	T_2, T_4	22	2	< 3						
5	25	125	.937	18/30	.255	T_5, T_4	9	3			289,063				
6	25	150	.952	18/30		T_5, T_4	4	2		3.456	187,500	<3	5.95		
	18.8	168.8	.925	18/30-13	.144	T_6, T_4	6	2	<10	5.6192	181,250	<3	5.80		
8	16.7	185.5	.937	18/30	.184	T_6, T_3	9	3		5.5296		<3	6.55		
9	16.7	202.2	.895	18/30/18	.154	T_6, T_3	7	2							
10	16.7	218.9	.876	18/30-17	.160	T_6, T_3	18	2		7.4493	134,375	<3	6.50		
11	16.7	235.6	.876	18/30	.135	T_6–T_1 T_3	25 – 3	2							
12	16.7	252.3	.916	18/30	.152	T_1–T_2 T_3	25 – 16	2	< 3	8.896	111,719	<5	6.10	172	15.05**

* Integrated System build on Contract NAS 9-16501
PWWWRS-SUHCP built on Contract NAS 9-15880

**Equivalent to approximately 32 ppm of urea

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 9

PWWWRS PRODUCT WATER QUALITY VERSUS

TENTATIVE WASH WATER STANDARDS

Parameter	Combined SUHCF/PWWWRS Test Results	"Stand-Alone" PWWWRS Test Results	Water Standard
Total Organic Carbon (TOC), mg/l	172	19 to 103	200
Specific Conductivity umho-cm^{-1} (resistivity:ohm-cm)	2.6 - 8.9 (111,000-370,000)	0.5 to 2 (400,000-2,000,000)	$\leq$ 2,000 ($\geq$ 500)
pH	5.4 to 7.2	6.3	5 to 7.5
Urea	32 (1)	10 (1)	50
NaCl	2 — 5	1	1,000

(1) as a function of TON

APPENDIX

The spacecraft utensil/hand cleansing fixture control panel wiring diagram is available on Drawing No. SK8ZG51 (code identification number 04236 Size D, Martin Marietta Corporation, NASA Contract NAS9-15880.

In the integrated prototype PWWWRS-SUHCF, the soap solenoid valve circuitry is not utilized in this panel. Removal of the non-functioning components in the panel was not done because of time and budget limitations.

Refer to Summary List 9, page A1, for contents of the Appendix.

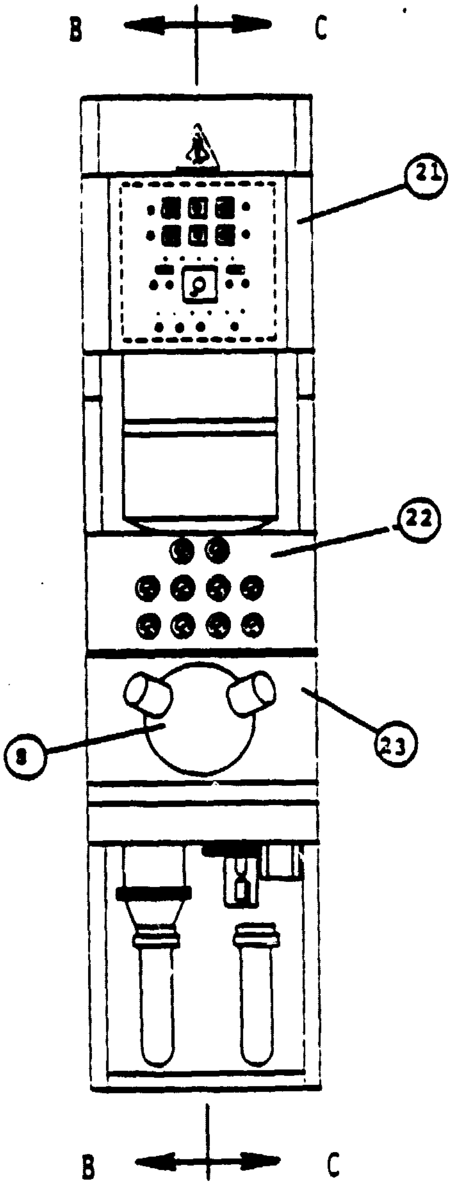
(The reverse of this page is blank.)

SUMMARY LIST 9

PARTS LIST & FIGURES

Parts List	Figure	Description
1	6	Prototype Major Components Front View
1	7	Prototype Right Side View
1	8	Prototype Left Side View
2	9	Control Components
3	10	Air Supply System
4	11	Soap and $FeCl_3$ System
5	12	Water Supply System
6	13	Mixing System
7	14	Waste Water System
8	15	Filter System
	16	Wiring Diagram
	17	Wiring Diagram
	18	Mixing Tank
	19	Waste Tank
	20	Prototype Frame
	21	Demonstration Hand Washing PWWWRS/SUHCF Prototype
	22	PWWWRS/SUHCF Recharging System
	23	REAR VIEW PWWWRS/SUHCF Sampling Valves at Top Mixing Tank and Deareator
	24	CP 162 Chassis
	25	Wiring Diagram

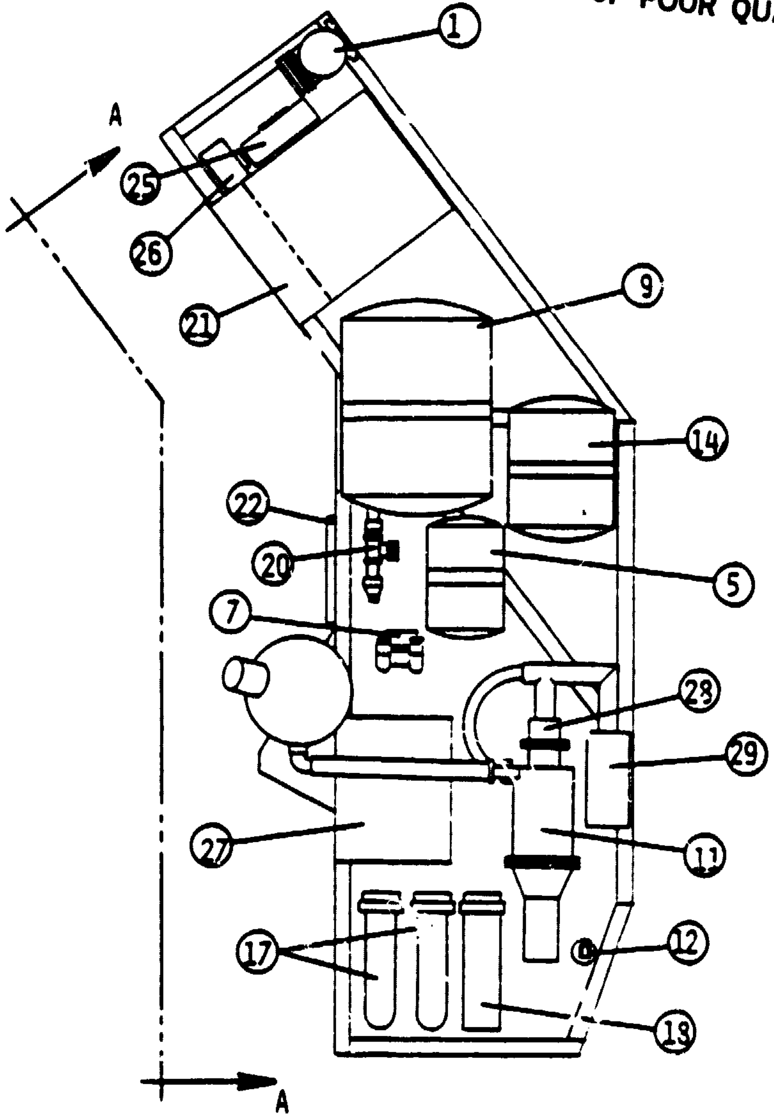
ORIGINAL PAGE IS
OF POOR QUALITY



VIEW AA

PWWWRS/SUHCF MAJOR COMPONENTS
FRONT VIEW

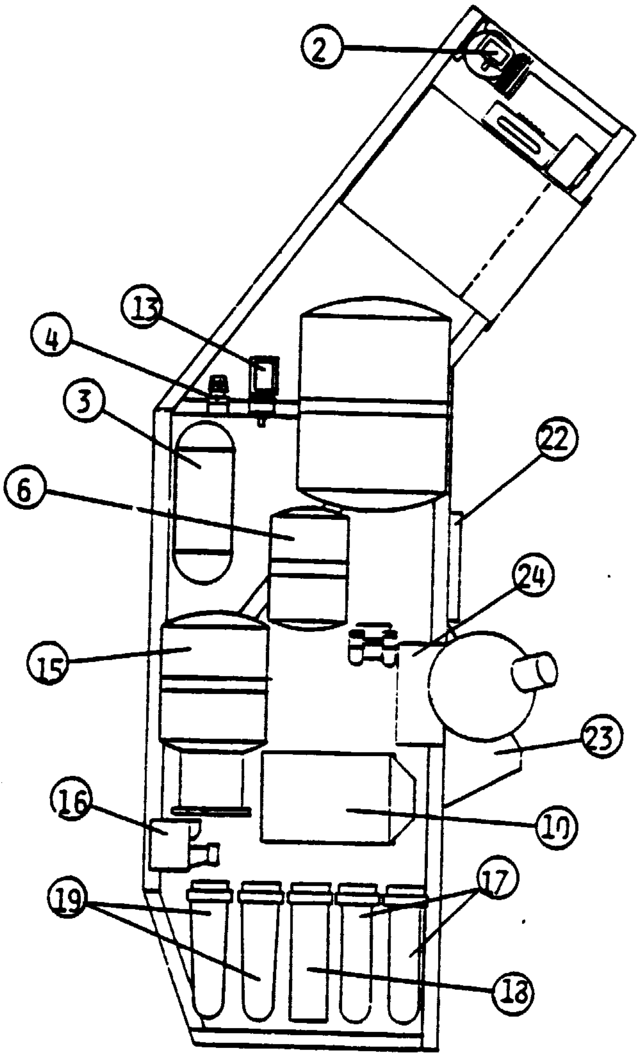
FIGURE 6



VIEW BB

PWWWRS/SUHCF
RIGHT SIDE VIEW

FIGURE 7



VIEW CC

PWWWRS/SUHCF
LEFT SIDE VIEW

FIGURE 8

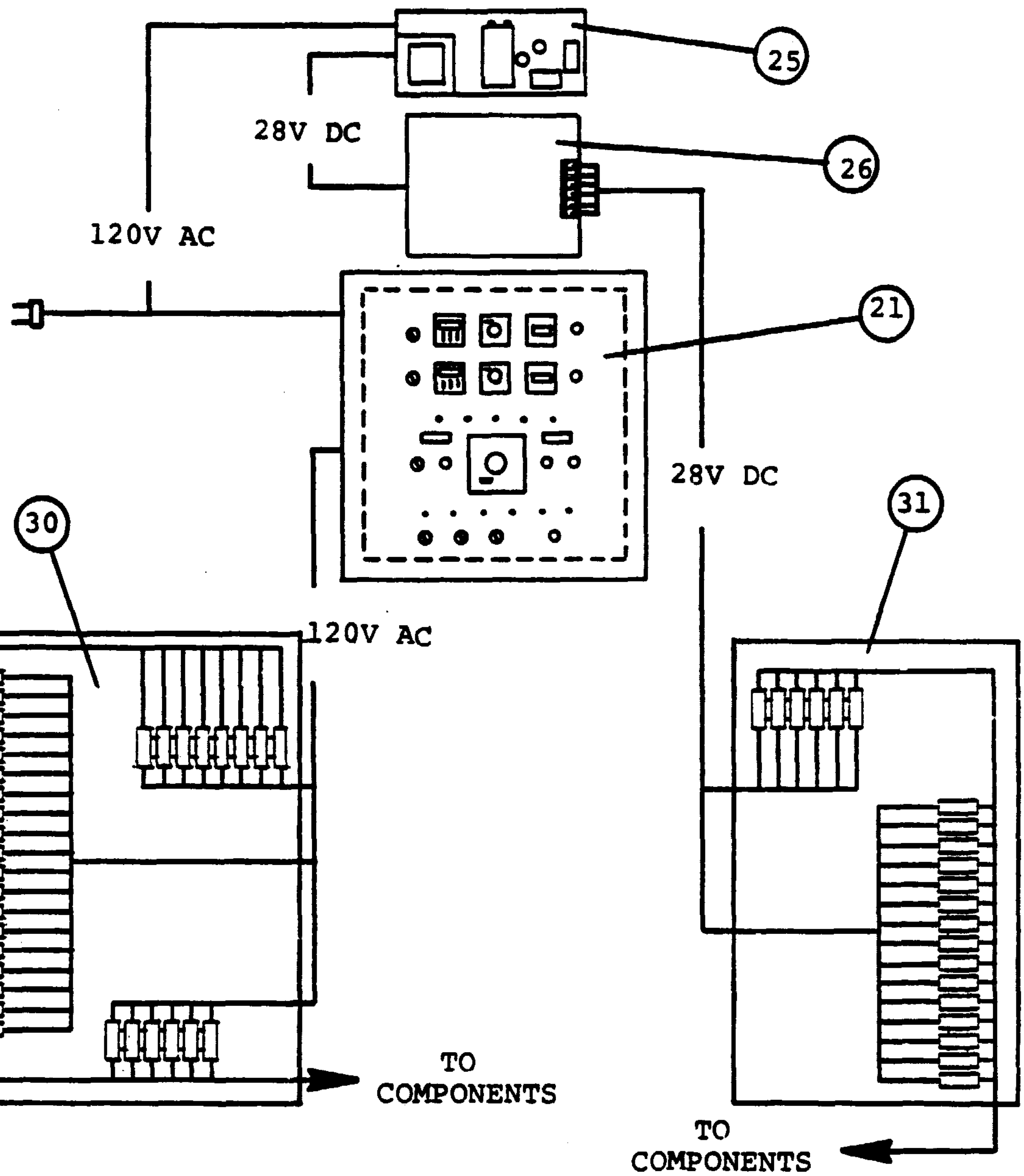
ORIGINAL PAGE IS
OF POOR QUALITY

Number	Part
1	Air Compressor
2	Pressure Switch
3	Air Storage Tank
4	Air Regulator
5	$FeCl_3$ Tank
6	Soap Tank
7	Dispense Valve
8	Hand Washing Enclosure
9	Supply Tank
10	SUHCF Water Heater
11	Liquid Gas Separator
12	Sump Pump
13	Pressure Switch
14	Waste Tank
15	Mixing Tank
16	Motor Actuated Ball Valve
17	String Filters
18	Ion Exchangers
19	Charcoal Filters
20	Conductivity Sensor
21	PWWWRS Control Panel
22	Pressure Gage Panel
23	SUHCF Hand Washing Enclosure Panel
24	SUHCF Valve Plate
25	SUHCF Control Plan
26	SUHCF Power Supply
27	PWWWRS Valve Plate
28	SUHCF Air Blow
29	SUHCF Charcoal Filter

PARTS LIST - MAJOR COMPONENTS
FOR FIGURES 6, 7, 8

LIST 1

ORIGINAL PAGE IS
OF POOR QUALITY



CONTROL COMPONENTS

FIGURE 9

ORIGINAL PAGE IS
OF POOR QUALITY

PART NO.	DESCRIPTION	MATERIAL	QTY.
21	PWWWRS Control Panel	Aluminum	1
25	SUHCF Power Supply	Aluminum	1
26	SUHCF Control Box	Aluminum	1
30	PWWWRS Valve Terminal Board	P.E. Clad	1
31	SUHCF Valve Terminal Board	P.E. Clad	1
	THFFN 16 Gage Wire	Copper	A/R
25	Power Supply-Power One Model CP162		
26	SUHCF Schematic Dwg SK82G51 Code 04236 Size D NASA Cont. NAS 1-15080		

PARTS LIST CONTROL COMPONENTS
FOR FIGURE 9

LIST 2

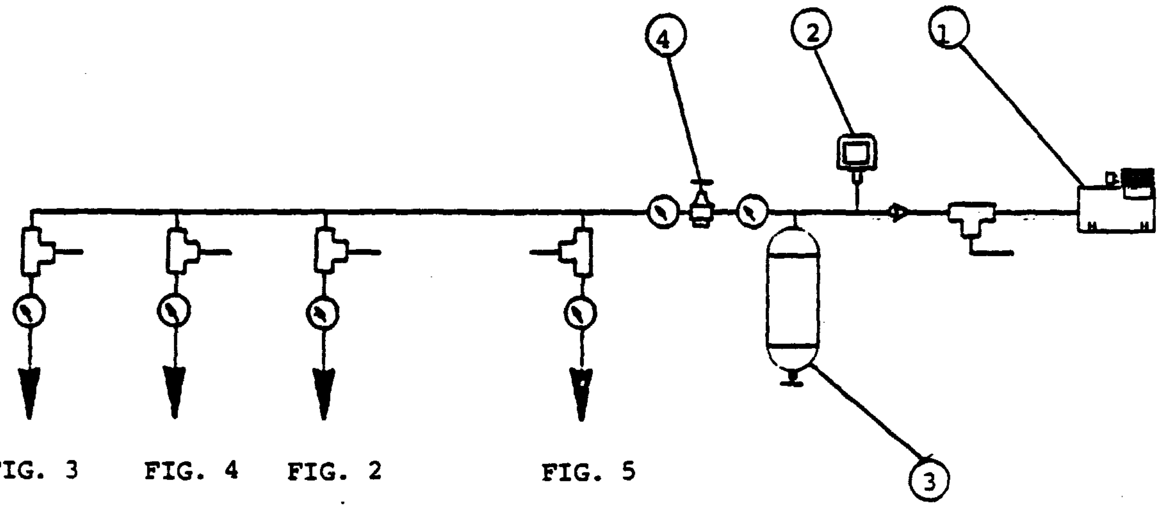


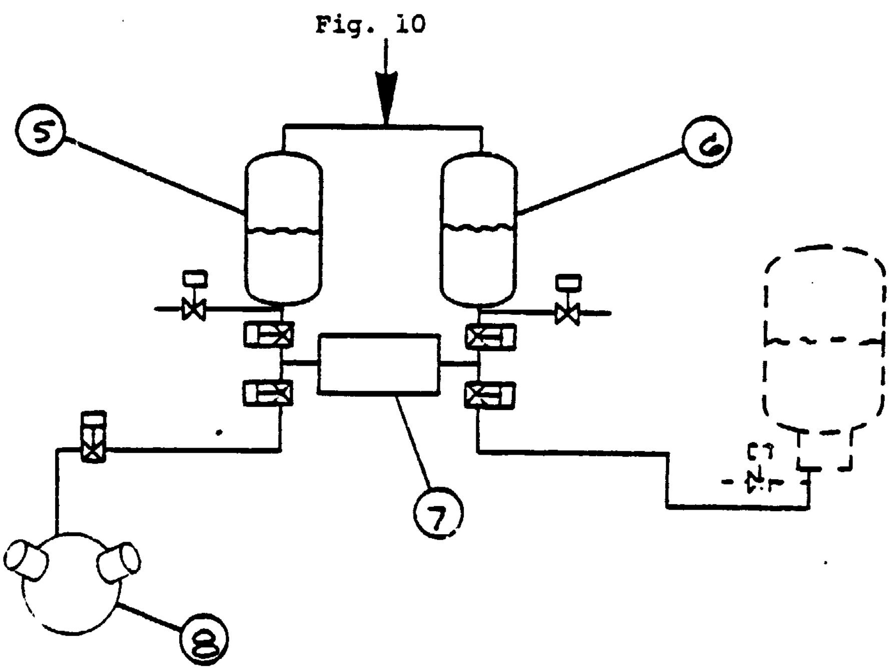
FIG. 3 FIG. 4 FIG. 2 FIG. 5

AIR SUPPLY SYSTEM

FIGURE 10

PART NO.	DESCRIPTION	MATERIAL	QTY.
1	Thomas Compressor 607CE40		1
	6-32 Soc. HD. Cap Screws	Steel	4
	Check Valve 1/4 NPT Parker	Stainless Steel	1
	6-4 CBZ Fitting Parker	Stainless Steel	2
	4-4 FHC Parker	Stainless Steel	1
	Skinner BB 3-Way Valve	Stainless Steel	5
	Valve Manifold	Brass	1
	Close Nipple 1/4" NPT	Stainless Steel	3
	Coupling 1/4" NPT	Stainless Steel	1
2	Square "D" Pumptroll Pressure Switch No. FHG-12		
	Mounting Bracket	Aluminum	1
	Cable Set, Screw Connector	Aluminum	2
	1/4-20 Soc. HD. Cap Screws	Steel	2
	4-4-4 Ft. Fitting Parker	Stainless Steel	2
3	2-Gallon Air Storage Tank ITT Numotive - Piggy Back Tank	Steel	1
	Modified Unistrut Pipe Strap 2062-50D	Steel	1
	Petcock 1/8 NPT	Brass	1
	Pressure Regulator Watts Model #R-364-02	Brass	1
	0-30 Psi Helicoid #3505-1 Gage	Brass	6
	6-4 FBZ Fitting Parker	Stainless Steel	5
	6-2 FBZ Fitting Parker	Stainless Steel	9
	6-2 DBZ Fitting Parker	Stainless Steel	6
	6-2 CBZ Fitting Parker	Stainless Steel	1
	6-6-4 RBZ Fitting Parker	Stainless Steel	1
	6-6-6 JBZ Fitting Parker	Stainless Steel	7
	6-2 TZHZBZ Fitting Parker	Stainless Steel	8
	Gould Imperial Eastman 66-P-3/8 Tubing	PE	A/R

PARTS LIST
AIR SUPPLY SYSTEM FIGURE 10
LIST 3



SOAP AND $FeCl_3$ SYSTEM

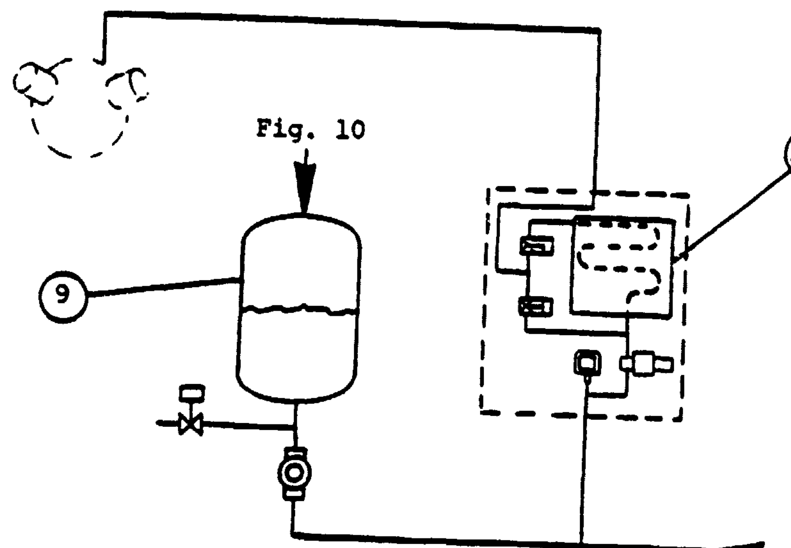
FIGURE 11

ORIGINAL PAGE IS
OF POOR QUALITY

PART NO.	DESCRIPTION	MATERIAL	QTY.
5		Steel	1
	3/4 to 1/4 NPT Coupling	Stainless Steel	1
	Modified SUHCF Tank Strap	Aluminum	2
	4-4-4 Ft. Fitting Parker	Stainless Steel	1
	6-4 CBZ Fitting Parker	Stainless Steel	1
	4-4 FBZ Fitting Parker	Stainless Steel	1
	5/16 - 32 to 1/4 NPT Coupling	Stainless Steel	2
6	FeCl Whitey SS 4254 Ball Valve	Stainless Steel	1
	Modified SUHCF Tank Strap	Aluminum	1
	Reducer Bushing 3/4-1/4 NPT	PVC	1
	10-24 SOC. Hd. Cap Screw	Steel	10
	Chem Cock Ball Valve	PVC	1
	P6MC4 Fitting Parker	PP	3
7	Dispensing Valve	Acrylic	1
	Dispensing Valve Bracket	Aluminum	1
	Female Pipe Tee 1/4 NPT	PVC	3
	Close Nipple 1/4 NPT	PVC	7
	6-4 FBZ Fitting Parker	Stainless Steel	2
	Nacon Eolinoid Valves WNE	Teflon	4
	Skinner B2 2-Way Valve	Stainless Steel	1
8	SUHCF Hand Washing Enclosure	Acrylic	1
	SUHCF Hand Washing Enclosure Panel	Steel	1
	6-4 HBZ Fitting Parker	Stainless Steel	1
	4-4 CBZ Fitting Parker	Stainless Steel	1
	Gould Imperial Eastman 66-P-3/8 Tubing	PE	A/R

PARTS LIST
FOR SOAP AND $FeCl_3$ SYSTEM FIGURE 11

LIST 4



WATER SUPPLY SYSTEM

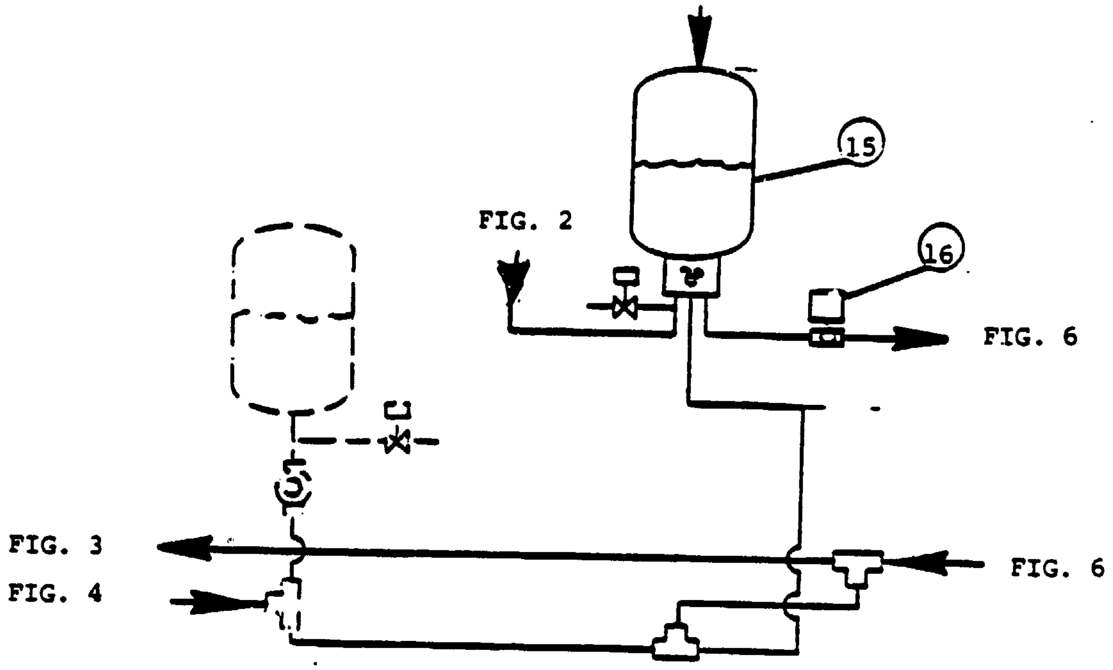
FIGURE 12

ORIGINAL PAGE IS
OF POOR QUALITY

PART NO.	DESCRIPTION	MATERIAL	QTY.
9			
	SUHCP Tank Strap	Aluminum	1
	SUHCP Flow Indicator	Brass	1
	6-4 CBZ Fitting Parker	Stainless Steel	1
	16-6 RB Fitting Parker	Stainless Steel	1
	5/16-32 to 1/4 NPT Coupling	Stainless Steel	1
	6-4 RB Fitting Parker	Stainless Steel	1
	Close Nipple 1/4 NPT	Stainless Steel	1
	4-4-4 Ft Fitting Parker	Stainless Steel	1
	6-6-6 JBZ Fitting Parker	Stainless Steel	1
	6-4 FBZ Fitting Parker	Stainless Steel	3
	4-4 FBZ Fitting Parker	Stainless Steel	1
	Whitey SS4234 Ball Valve	Stainless Steel	1
10	SUHCP Water Heater		1
	Micro Pump #12A-31-316	Stainless Steel	1
	1/4-20 SOC Hd. Cap Screw	Steel	8
	SUHCP Pressure Switch		1
	Sweglok Pressure Release Valve	Stainless Steel	1
	4-4 CBZ Fitting Parker	Stainless Steel	1
	4-4-4 JBZ Fitting Parker	Stainless Steel	4
	4-4 CBZ Fitting Parker	Stainless Steel	7
	6-4 HBZ Fitting Parker	Stainless Steel	1
	Skinner BZ 2-Way Valve	Stainless Steel	2
	1/4" OD Tubing x .035 Wall	Stainless Steel	A/R
	3/8 OD Tubing x .035 Wall	Stainless Steel	A/R

PARTS LIST
WATER SUPPLY SYSTEM FOR FIGURE 12

LIST 5



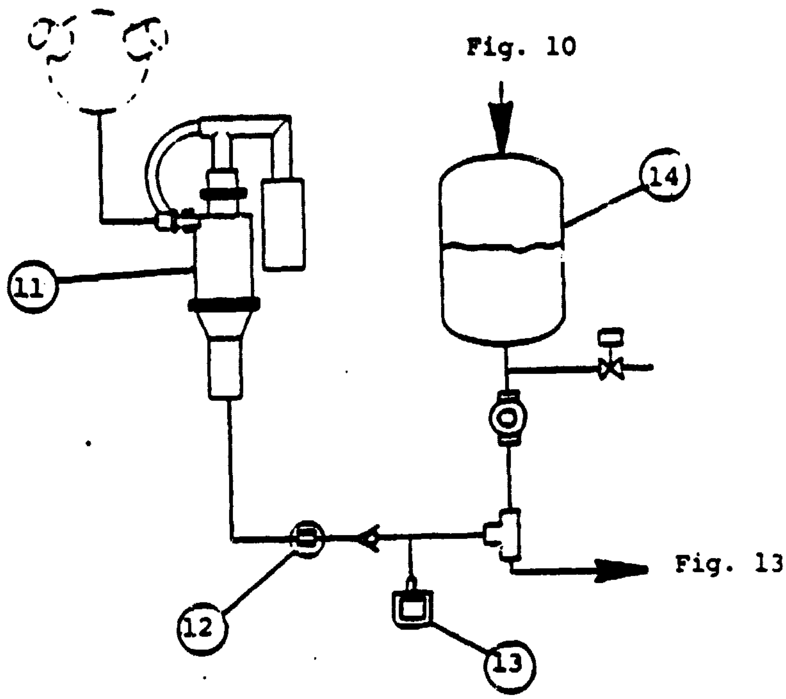
MIXING SYSTEM
FIGURE 13

PART NO.	DESCRIPTION	MATERIAL	QTY.
15			
	Modified Unistrut Pipe Strap P2070-81	Steel	1
	Jet Agitator - Spraying Systems Co. No. 6290-SS	Brass	1
	Gasket	Cork	1
	Skinner B.3 3-Way Valve	Stainless Steel	2
	5/16-32 to 1/4 NPT Coupling	Stainless Steel	1
	6-2 CBZ Fitting Parker	Stainless Steel	6
	6-4 CBZ Fitting Parker	Stainless Steel	2
	12-8 RB Fitting Parker	Stainless Steel	1
	8-4 RB Fitting Parker	Stainless Steel	1
	8-8 MHN-2" Fitting Parker	Stainless Steel	1
	8-8 FHC Fitting Parker	Stainless Steel	1
	8-8 MHN Fitting Parker	Stainless Steel	1
	Close Nipple 1/4 NPT	PVC	3
	Elbow 1/4 NPT	PVC	1
	Chem Cock Ball Valve	PVC	1
	P6FC4 Fitting Parker	PP	1
16	Jenkins Motor Actuated Ball Valve #202	Stainless Steel	1
	Gould Imperial Eastman 66-P-3/8	PE	A/R

PARTS LIST
MIXING SYSTEM FIGURE 13

LIST 6

ORIGINAL PAGE IS
OF POOR QUALITY



WASTE WATER SYSTEM

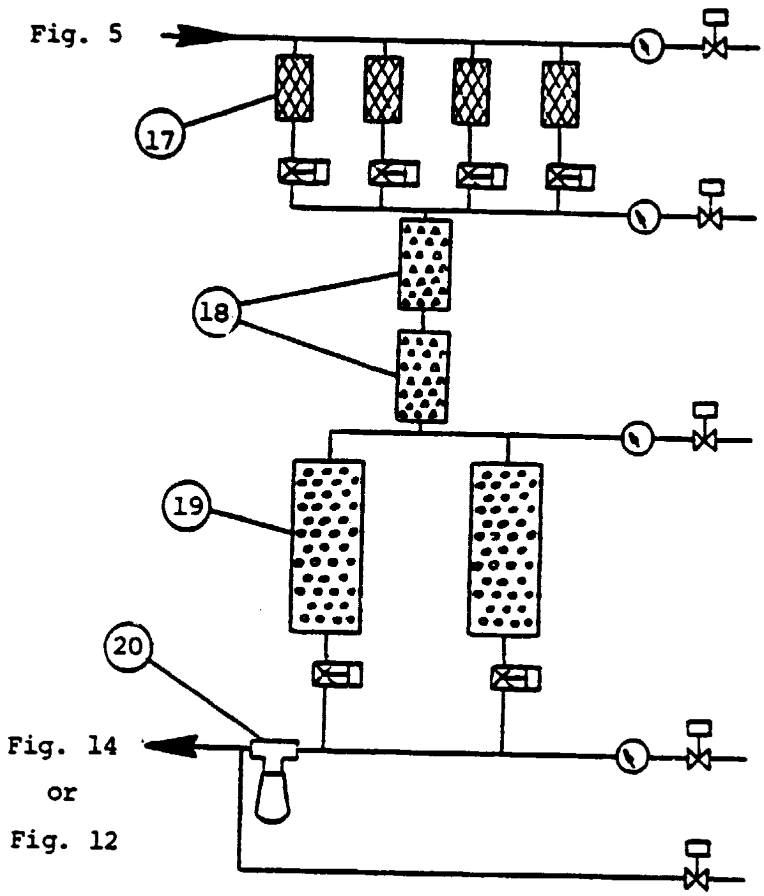
FIGURE 14

ORIGINAL PAGE IS
OF POOR QUALITY

PART NO.	DESCRIPTION	MATERIAL	QTY.
11	SUNCF Liquid Gas Separator	Acrylic	1
	Liquid Level Control - SUNCF		1
	SUNCF Charcoal Filter	Aluminum	1
	3" Hose Clamp	Steel	6
	SUNCF Air Blower	Steel	1
	SUNCF Mounting Straps	Aluminum	2
12	Micro Pump Magnetic Drive #V20-306-0000	Aluminum	1
	Micro Pump Bracket	Aluminum	1
	1/4-20 SOC. HD. Cap Screw	Steel	4
	Sweglok Check Valve	Stainless Steel	1
	4-4 FBZ Fitting Parker	Stainless Steel	3
	4-4 CBZ Fitting Parker	Stainless Steel	2
	6-4 HBZ Fitting Parker	Stainless Steel	1
13	Square "D" Pressure Switch #9012		1
14			
	Modified Unistrut Pipe Strap #P207081	Steel	1
	SUNCF Flow Indicator	Brass	1
	Skinner BB 3-Way Valve	Stainless Steel	1
	6-4 FBZ Fitting Parker	Stainless Steel	2
	6-4 CBZ Fitting Parker	Stainless Steel	1
	6-2 CBZ Fitting Parker	Stainless Steel	3
	6-6 EBZ Fitting Parker	Stainless Steel	1
	6-6-6 JBZ Fitting Parker	Stainless Steel	1
	5/16-32 to 1/4 NPT Coupling	Stainless Steel	1
	12-4 RB Fitting Parker	Stainless Steel	1
	Close Nipple 1/4 NPT	Stainless Steel	2
	6-6-6 Ft Fitting Parker	Stainless Steel	1
	Whitey SS4254 Ball Valve	Stainless Steel	1
	Gould Imperial Eastman 66-P-3/8 Tubing	PE	A/R

PARTS LIST
WASTE WATER SYSTEM FIGURE 14

LIST 7



FILTER SYSTEM

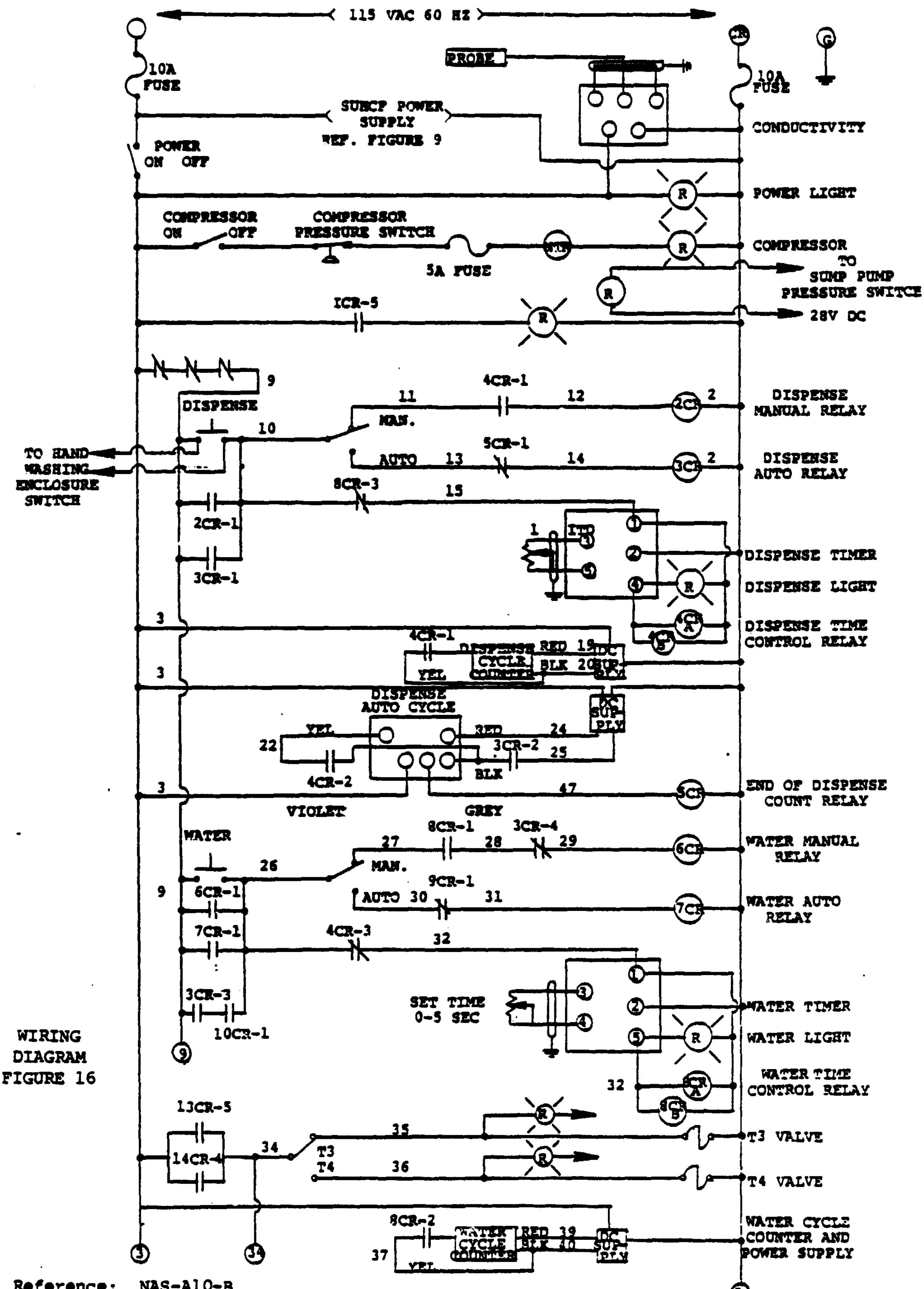
FIGURE 15

ORIGINAL PAGE IS
OF POOR QUALITY

PART NO.	DESCRIPTION	MATERIAL	QTY.
17	AMF Cuno Filter Housing #CT 101 3/4" NPT	# 4152-01 Stainless Steel & Brass	4
	AMF String Filter Cartridge Micro-Wynd II	DPPPY	4
18	AMF Cuno Filter Housing #1M1 3/4" NPT	Plastic Acrylic/Styrene	2
	AMF Activated Carbon Cartridge	Cat. No. 46285-01	2
19	AMF Cuno Penfield Water Conditioner Housing		2
	AMF Ion Exchange Resin Ref: Model SM04010 Demineralizer		2 Bags
	Filter Manifold	Aluminum	1
	Shaw-Walker Draw Slide	Steel	1 Pair
	1/4-20 Soc. Hd. Cap Screw	Steel	34
	6-2 CBZ Fitting Parker	Stainless Steel	16
	12-4 RB Fitting Parker	Stainless Steel	16
	6-6-6 JBZ Fitting Parker	Stainless Steel	15
	Skinner B2 2-Way Valve	Stainless Steel	6
	6-2 FBZ Fitting Parker	Stainless Steel	9
	6-2 CBZ Fitting Parker	Stainless Steel	4
	6-2 T2H2BZ Fitting Parker	Stainless Steel	4
	Valve Manifold	Brass	1
	Parker Vall Valve #172F	Stainless Steel	5
	0-30 Psi Heliloid Gages #3505-1	Brass	4
20	Leeds & Northrup Conductivity Cell Catalog 7086-1-7-000	Plastic	1
	Female Pipe Tee 3/4 NPT	Brass	1
	2" Nipple 3/4 NPT	Brass	1
	12-4 RB Fitting Parker	Stainless Steel	1
	Coupling 3/4 to 1/2 NPT	Brass	1
	Reducer Bushing 1/2 to 1/4 NPT	PP	1
	6-4 CBZ Fitting Parker	Stainless Steel	1
	6-6-4 RBZ Fitting Parker	Stainless Steel	1
	6-4 DBZ Fitting Parker	Stainless Steel	4

PARTS LIST
FILTER SYSTEM FIGURE 15

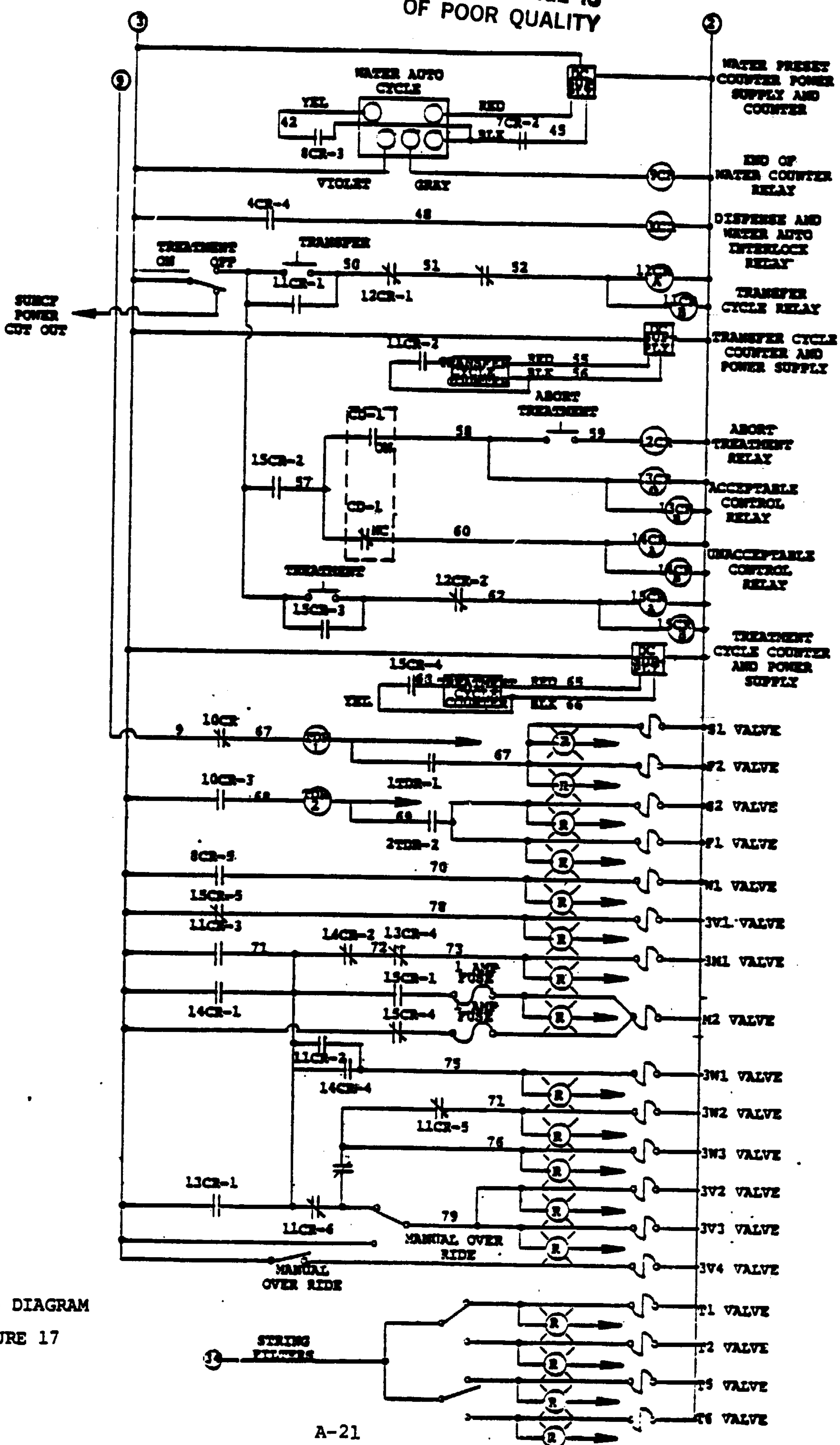
LIST 8



WIRING DIAGRAM
FIGURE 16

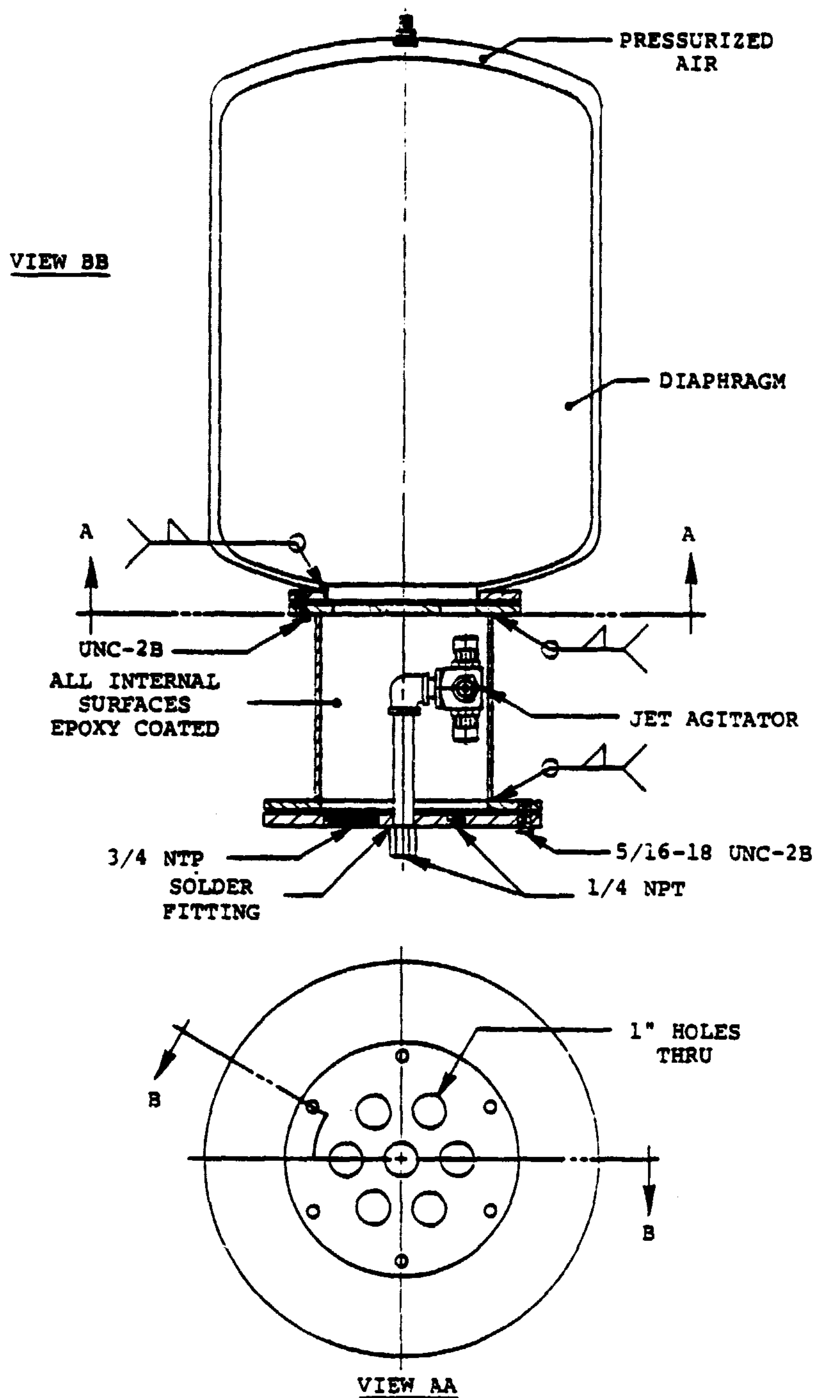
Reference: NAS-A10-B

ORIGINAL PAGE IS
OF POOR QUALITY



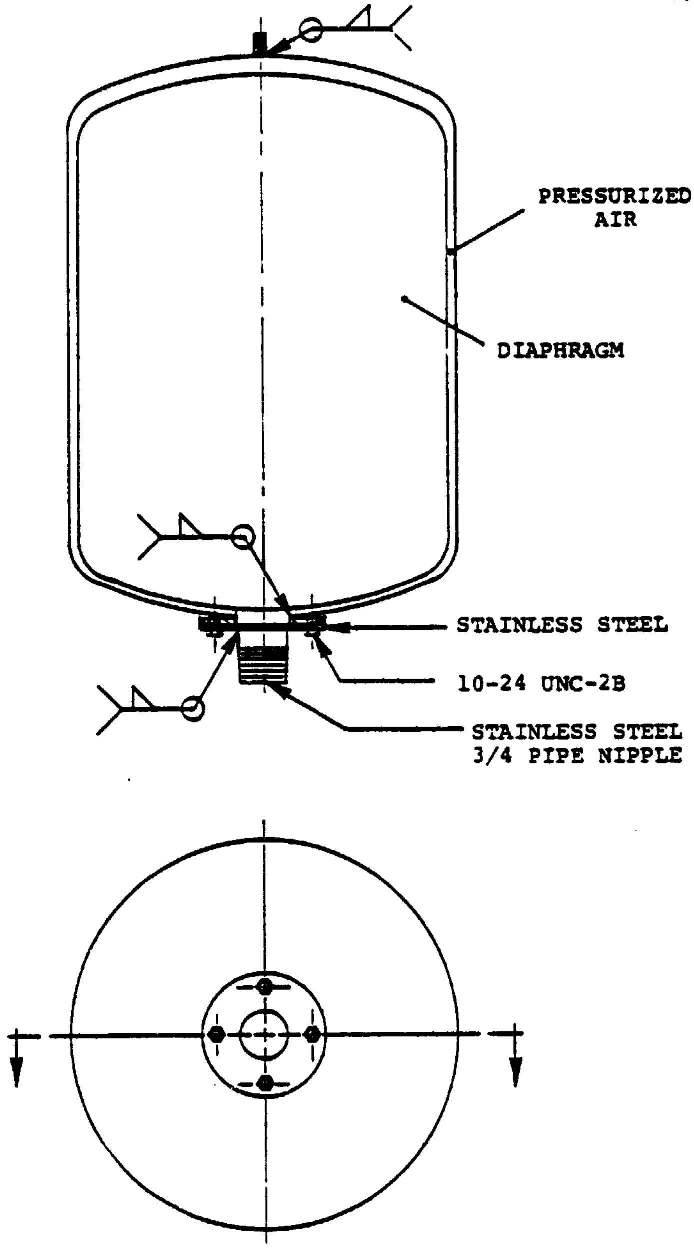
WIRING DIAGRAM

FIGURE 17



MIXING TANK

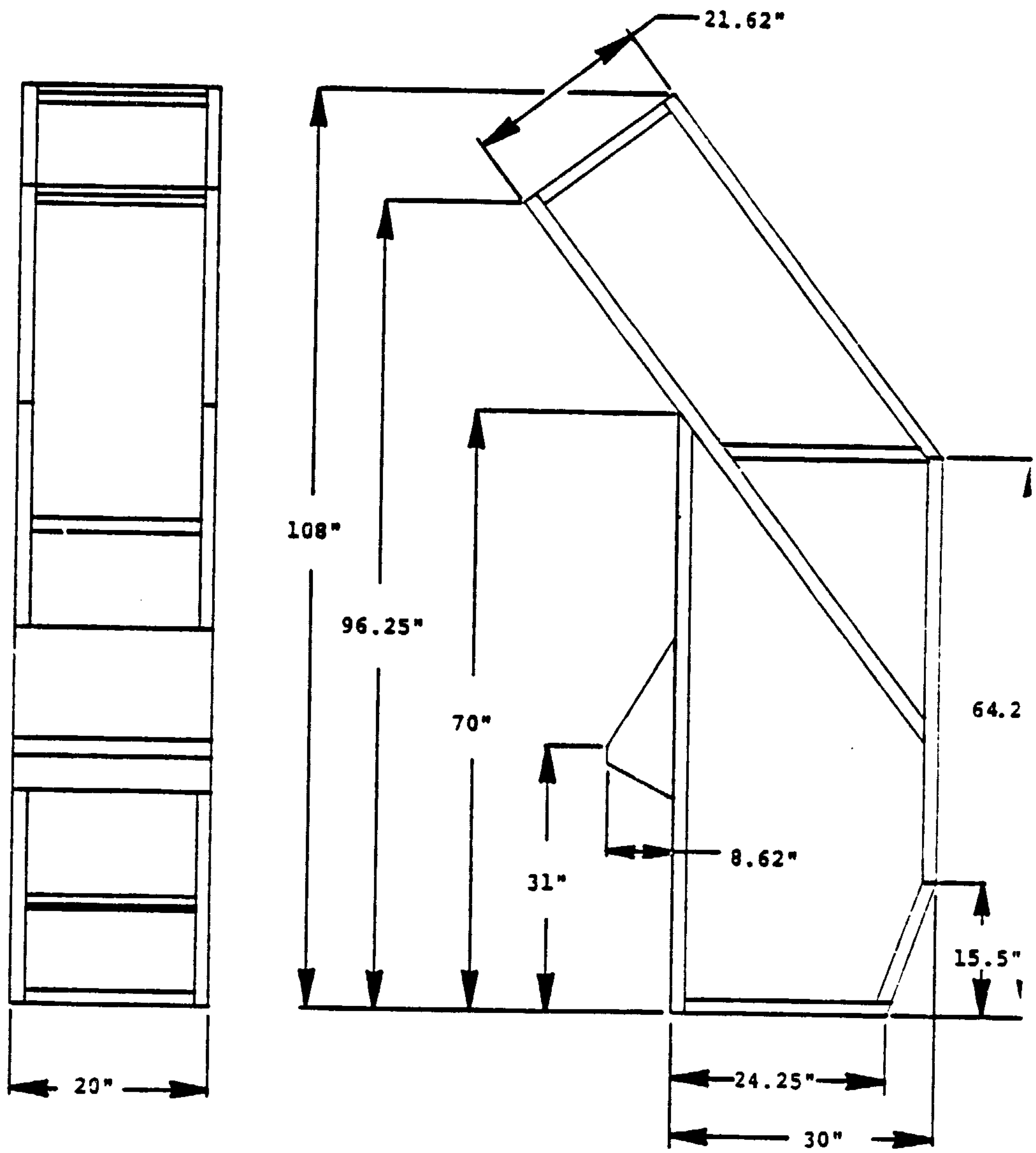
FIGURE 18



WASTE TANK

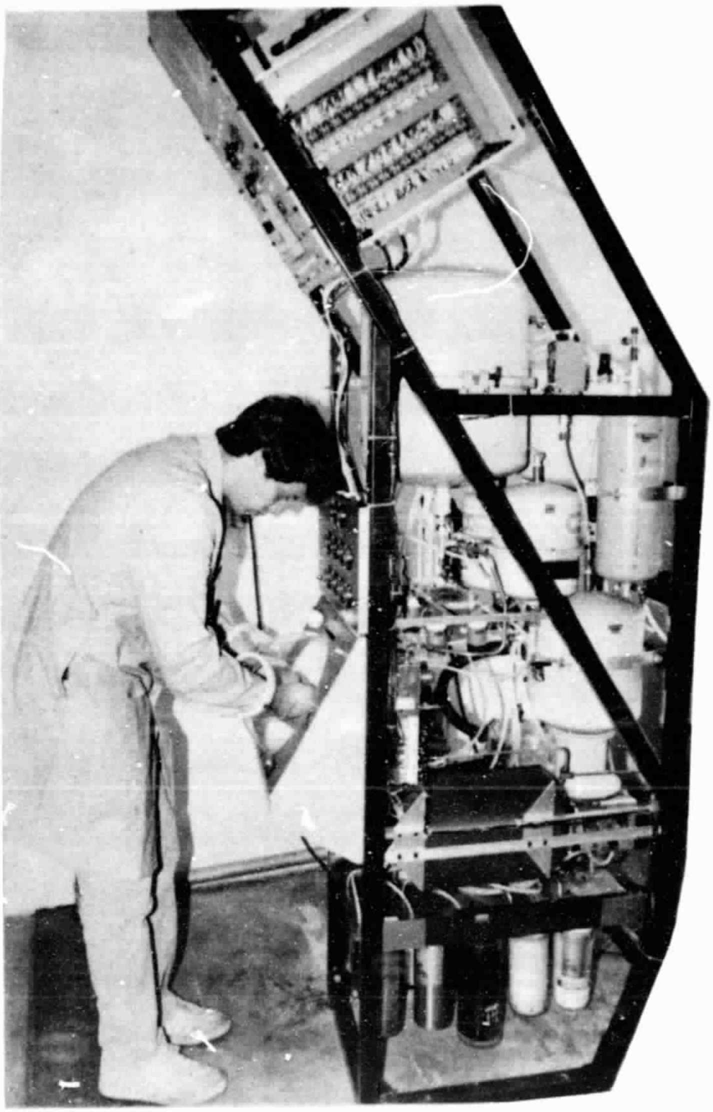
FIGURE 19

ORIGINAL PAGE IS
OF POOR QUALITY



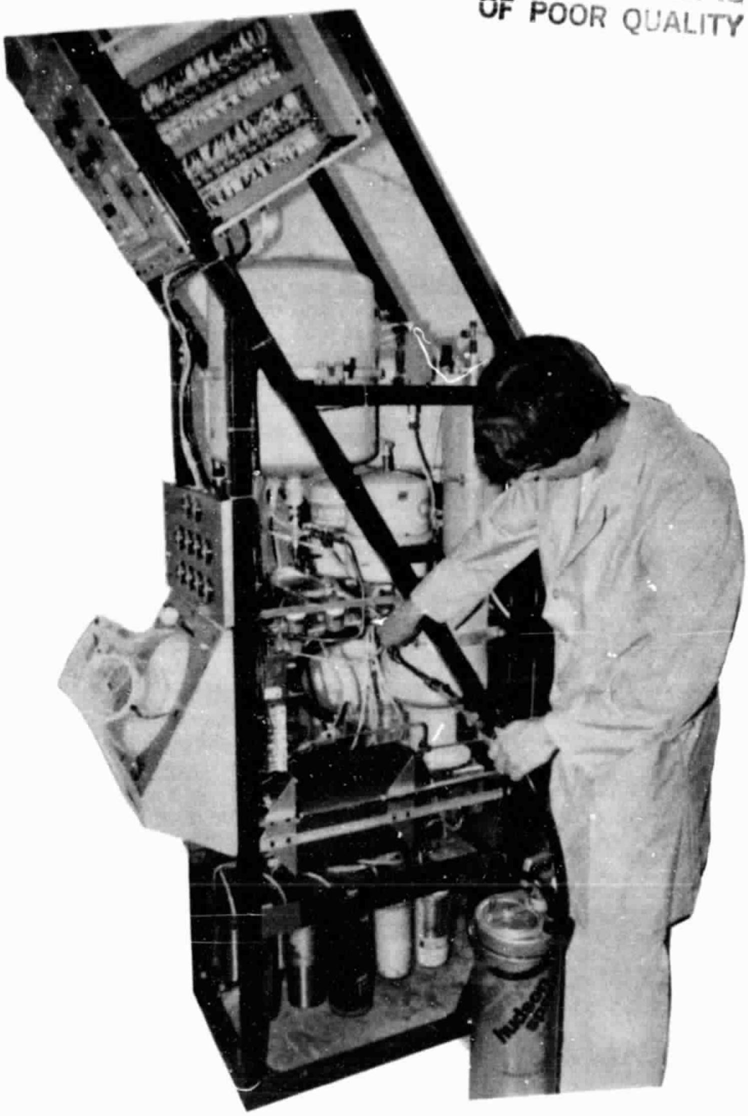
PROTOTYPE PWWWRS/SUHCF
FRAME

FIGURE 20



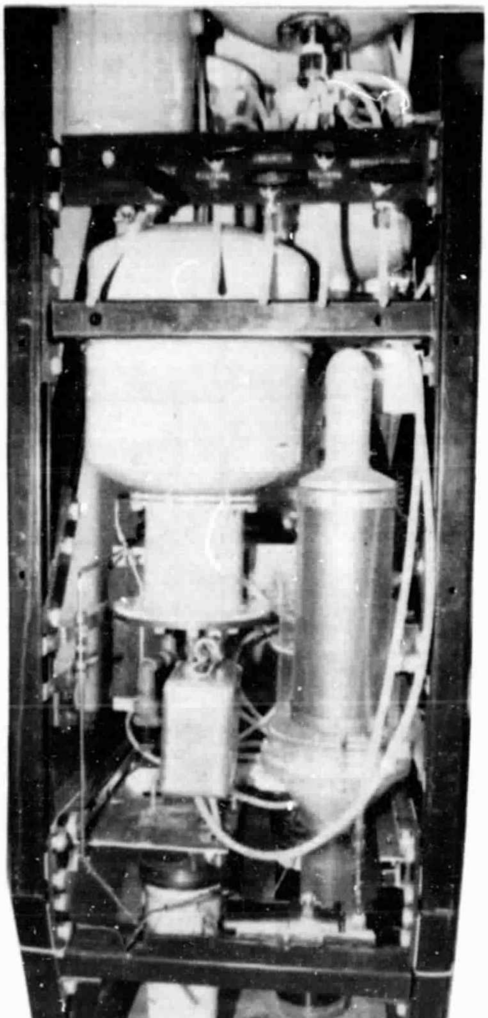
DEMONSTRATION HAND WASHING
PWWWRS/SUHCF PROTOTYPE

FIGURE 21



PWWWRS/SUHCF
RECHARGING SYSTEM

FIGURE 22



SAMPLING VALVES

LEFT TO RIGHT

SUPPLY

FILTER IN

ION EXCHANGE IN

CONDUCTIVITY

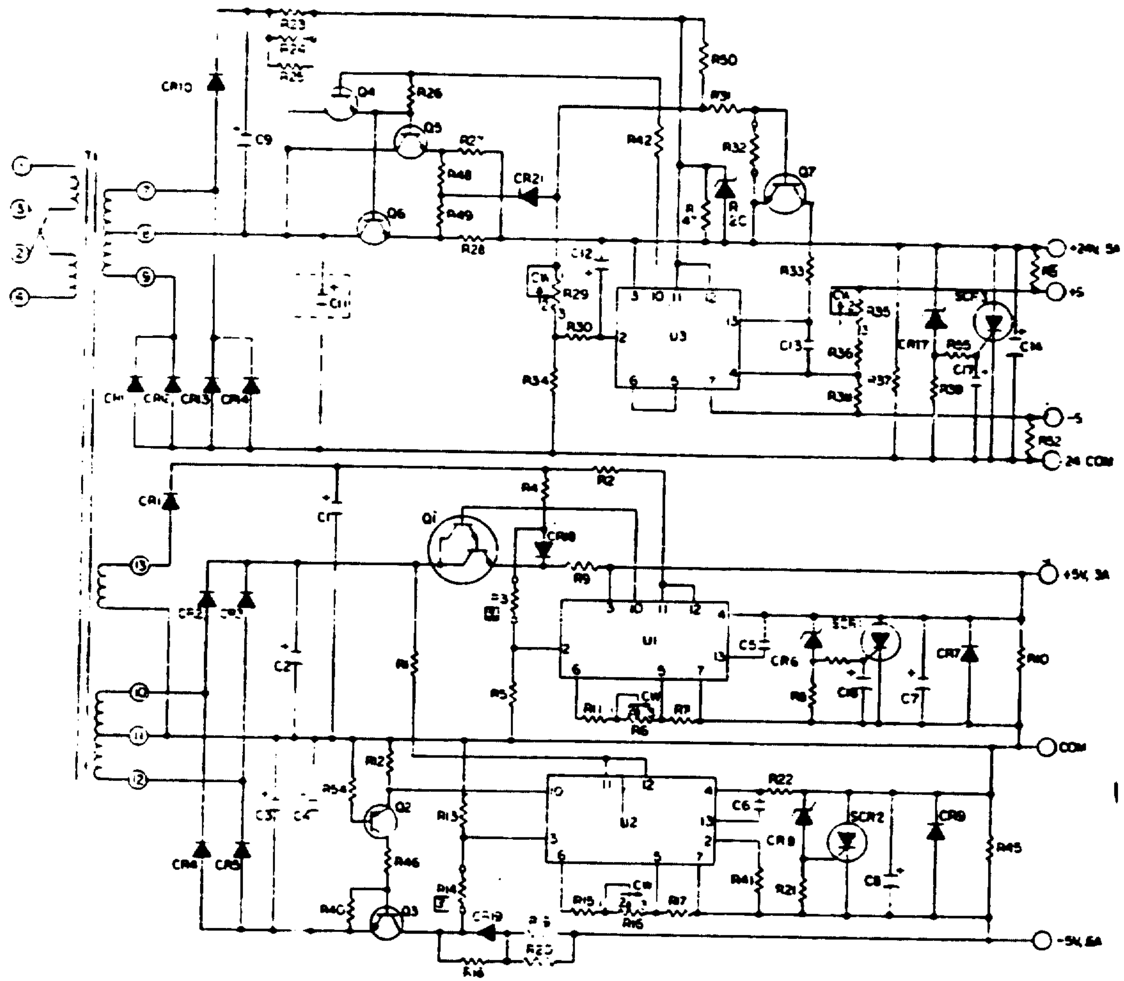
FILTER OUT

REAR VIEW

PWWWRS/SUHCF

SAMPLING VALVES AT TOP
MIXING TANK AND DEAREATOR

FIGURE 23



INSERT R3 IN STUFFING BEFORE SOLDER FLOW.
SELECT IN TEST TO BE INSTALLED IN FINAL TEST
ALL VOLTAGES REF TO COMMON OUTPUTS
VOLTAGE MEASUREMENTS @ 115 VAC INPUT, FULL LOAD ON OUTPUT
NOTES: UNLESS OTHERWISE SPECIFIED

C17,C18	40/25	CAPACITOR, ELECT.	[illegible]
C16	25/63	ELECT.	[illegible]
C15	[illegible]	MYLAR	[illegible]
C11	15000/50	ELECT.	[illegible]
C9,C12	47/50	ELECT.	[illegible]
C7,C8	220/25	ELECT.	[illegible]
C5,C6	20/100	MYLAR	[illegible]
C3,C4	4000/16	ELECT.	[illegible]
C2	9000/25	ELECT.	[illegible]
C1	4000/35	CAPACITOR, ELECT.	[illegible]
[illegible]	1N4003	DIODE, 1A, 200V	[illegible]
CR17	1N914B	ZENER	[illegible]
[illegible]	[illegible]	ZENER	[illegible]
[illegible]	1N5400	DIODE, 3A, 400V	[illegible]
SCR3	[illegible]	SCR, 3A	[illegible]
SCR1,2	[illegible]	SCR, 5A	[illegible]
Q7	[illegible]	TRANSISTOR	[illegible]
Q5,6	[illegible]		[illegible]
Q3	[illegible]		[illegible]
Q2	[illegible]		[illegible]
Q1	[illegible]	TRANSISTOR	[illegible]
R27,28	.22 Ω	RESISTOR, 2%, 10W, W.W.	[illegible]
R9	.12 Ω	2%, W.W.	[illegible]
R10	12K	1/4W, 2%, MF	[illegible]
[illegible]	2.2K	1/4W, 2%, MF	[illegible]
[illegible]	12K	1/4W, 5%, CF	[illegible]
[illegible]	7.6K		[illegible]
[illegible]	2.7K		[illegible]
[illegible]	3.1K		[illegible]
[illegible]	30K		[illegible]
[illegible]	10K		[illegible]
[illegible]	22K		[illegible]
[illegible]			
[illegible]	2.7 Ω		[illegible]
[illegible]	75 Ω		[illegible]
[illegible]	[illegible]		[illegible]
[illegible]	150 Ω		[illegible]
[illegible]	220 Ω		[illegible]
[illegible]	47 Ω	RESISTOR, 1/4W, 5%, CF	[illegible]
[illegible]	2K	POTENTIOMETER	[illegible]
U1,2,3	[illegible]	I.C. VOLTAGE REGULATOR	[illegible]
PC A		PRINTED CIRCUIT BOARD	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

MODEL: CP162 TRIPLE OUTPUT

EDITION NO. 2

INFORMATION CONTAINED:
1. SCHEMATIC
2. PARTS LIST
3. SPECIFICATIONS
4. OUTLINE AND MOUNTING
5. GENERAL USER INFORMATION

power-one INC
AC POWER SUPPLIES

APPLICATION DATA SHEET

AC CONNECTION TABLE

INPUT 50-60HZ	JUMPER	APPLY AC	FUSE
115 VAC	1 & 3 , 2 & 4	1 & 4	3.0A
230 VAC	2 & 3	1 & 4	1.5A

OUTPUT RATING CHART

VOLTS	AMPS STEADY	AMPS SURGE	OVP
+5.0	3.0	———	6.2 ± .4 VDC
-5.0	0.6	———	6.2 ± .4 VDC
+24.0	5.0	6.0	———

A.C. INPUT: 115/230 VAC ± 10% 47-400 HZ (DERATE OUTPUT CURRENT 10% FOR 50HZ OPERATION)

D.C. OUTPUT: SEE OUTPUT RATING CHART. ADJUSTMENT RANGE, ±5% MINIMUM.

OUTPUT RIPPLE: 2 TO 15V OUTPUTS 5.0 mV PK-PK MAXIMUM. 20 TO 200V OUTPUTS 5.0 mV PK-PK MAXIMUM.

LINE REGULATION: ±.05% FOR A 10% LINE CHANGE.

LOAD REGULATION: ±.05% FOR A 50% LOAD CHANGE.

TRANSIENT RESPONSE: 50μSECONDS FOR A 50% LOAD CHANGE.

STABILITY: ±.3% FOR 24 HOURS AFTER WARM UP.

TEMPERATURE RATING: 0° TO 50°C FULL RATED, DERATE LINEARLY TO 40% AT 70°C.

TEMP COEFFICIENT: ±.03% / °C MAXIMUM .010% / °C TYPICAL.

VIBRATION: PER MIL-STD-810C; METHOD 514, PROCEDURE X.

SHOCK: PER MIL-STD-810C, METHOD 516, PROCEDURE V.

SHORT CIRCUIT &

OVERLOAD PROTECTION: AUTOMATIC CURRENT LIMIT / FOLDBACK.

COOLING: CONVECTION COOLING IS ADEQUATE WHERE NON RESTRICTED AIR FLOW IS AVAILABLE. WHEN OPERATING IN A CONFINED AREA, MOVING AIR OR CONDUCTION COOLING IS RECOMMENDED.

OVERVOLTAGE PROTECTION: SEE OUTPUT RATING CHART.

REMOTE SENSING: LEAD PROTECTION BUILT-IN.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

WARRANTY

POWER-ONE WARRANTS EACH POWER SUPPLY OF ITS MANUFACTURE THAT DOES NOT PERFORM TO PUBLISHED SPECIFICATIONS, AS A RESULT OF DEFECTIVE MATERIALS OR WORKMANSHIP, FOR A PERIOD OF TWO (2) FULL YEARS FROM THE DATE OF ORIGINAL DELIVERY. RETURNS MUST BE FREIGHT PREPAID.

POWER-ONE ASSUMES NO LIABILITIES FOR CONSEQUENTIAL DAMAGES OF ANY KIND THROUGH THE USE OR MISUSE OF ITS PRODUCTS BY THE PURCHASER OR OTHERS. NO OTHER OBLIGATIONS OR LIABILITIES ARE EXPRESSED OR IMPLIED.

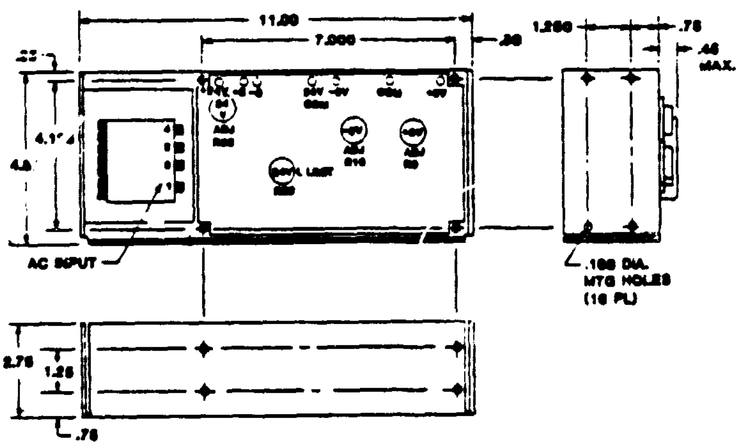
IMPORTANT:

THIS POWER SUPPLY FEATURES REMOTE SENSING CAPABILITY. REMOTE SENSING TERMINALS ARE PROVIDED FOR HOOK-UP WHEN USED IN APPLICATIONS UTILIZING THIS FEATURE.

WHEN NOT USING REMOTE SENSING, OR WHEN TESTING THE UNIT TO ITS SPECIFICATIONS, THE REMOTE SENSING TERMINALS SHOULD BE CONNECTED TO THEIR RESPECTIVE OUTPUT TERMINALS AS FOLLOWS:

+S TO + OUT
-S TO - OUT

ORIGINAL PAGE IS OF POOR QUALITY



CP162 CHASSIS
UNIT WEIGHT 9 LBS

CP162 CHASSIS

FIGURE 24